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INSTITUTE FOR DEFENSE ANALYSES

# Developing Education and Training Requirements for the Systems Planning, Research, Development, and Engineering/Systems Engineering Career Path

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December 2004



IDA Paper P-3951
Log: H 04-002294

This work was conducted under contracts DASW01 04 C 0003/ W74V8H 05 C 0042, Task AB-6-2271, for the Office of the Director, Defense Systems. The publication of this document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

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# PREFACE

This paper documents work performed by the Institute for Defense Analyses (IDA) in partial fulfillment of the task titled "Systems Engineering in the New Acquisition Process." The Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics), Office of Enterprise Development in the Office of Systems Engineering (SE) sponsored this work.

This paper presents IDA's work in examining systems engineering-related education and training for the acquisition workforce to enhance the implementation of systems engineering—specifically, work done in reviewing and recommending revisions to the Defense Acquisition University (DAU) courses for the Systems Planning, Research, Development, and Engineering/Systems Engineering (SPRDE/SE) career path.

The authors wish to thank the reviewers, Karen Tyson and Lance Hancock of IDA and Ann Marie Choephel from OUSD(AT&L) DS/SE/ED Quadelta. In addition, the authors wish to thank the editor, Shelley Smith of IDA.

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# SUMMARY

In FY2004, the Systems Engineering office asked the Institute for Defense Analyses (IDA) to participate in a review of the systems engineering-related education and training offered by the Defense Acquisition University (DAU) and to determine ways that it could be revised or updated to achieve better implementation of systems engineering in acquisition programs. Most of the work centered on the courses offered within the Systems Engineering (SE) career path of the Systems Planning, Research, Development and Engineering (SPRDE) career field. The purpose of this paper is to document IDA's participation in this effort.

At the time of this review, DoD was in the midst of a department-wide transformation. The DoD 5000 series had been updated, a new "requirements" development process called JCIDS (Joint Capabilities Integration Development System) was adopted, and systems engineering was undergoing revitalization. All of these updates and initiatives needed to be reflected in SPRDE/SE education and training elements and materials such as the SPRDE/SE position category description, certification requirements, guidance regarding certification course content (referred to in the paper as "competencies"), certification course content, and other education and training-related resources.

The review was a collaborative effort involving the Systems Engineering office, DAU, and other members of the SPRDE/SE Functional Integrated Process Team (FIPT)—the team responsible for managing the SPRDE/SE career path. The SPRDE/SE FIPT, led by the Deputy Director of Enterprise Development in the Systems Engineering Office, was ultimately responsible for the review and for providing guidance to DAU regarding needed revisions and updates to the certification course material and other education and training related resources. DAU, as the developer of education and training resources, was responsible for updating and revising the education and training resources based on the FIPT's guidance.

IDA supported this effort by proposing an overall approach to reviewing SPRDE/SE education and training requirements, guidance and materials, and by using that approach to develop a list of duties and tasks that today's SPRDE/SE professionals perform. These duties and tasks were intended to serve as guidance from the FIPT to

DAU SPRDE/SE curriculum developers. The review approach IDA proposed and used was a combined top-down and bottom-up approach. The top-down review consisted of reviewing current DoD and Systems Engineering policy guidance and initiatives, systems engineering processes and activities, and best practices. The bottom-up review, on the other hand, was a review of current SPRDE/SE certification course content, and existing and past guidance for those courses. Combining these two approaches allowed IDA to revise and build upon existing guidance while incorporating new elements relevant to today's DoD acquisition environment. The products of the review, including IDA's main product, the SPRDE/SE Duties and Tasks (found in appendix K) are included among the appendixes to this paper.

Included below are process-related recommendations resulting from IDA's experience in the review:

*Recommendation 1:* Conduct a more thorough requirements analysis of SPRDE/SE acquisition personnel and their needs for SPRDE/SE training. In the course of the review, we did not have the time to do as much of the requirements development process, one of the most important processes in systems engineering, as we would have liked. Having a better sense of the requirements would have led to more complete criteria for reviewing the courses. It would be interesting, for example, to examine the areas where systems engineers have the most trouble in programs, and to emphasize those areas in the SPRDE/SE education and training. We attempted to do this through previous studies but did not have the real-time data that we needed. An analysis like this might also be useful in determining whether the certification courses are the resources that need update and investment or if courses that are more widely available on-demand (such as Continuous Learning Modules (CLMs)) might be a better approach. The assessment data needs to feed into the FIPT process.

*Recommendation 2:* DAU should clarify and standardize instructional terminology. If, rather than mandating use of a specific process, DAU wants to ensure that each of the FIPTs can be flexible in their management of the career fields and paths, it would be helpful if DAU defined its terminology generically enough to allow for this variation. While the instructional terminology definitions in Chapter II are helpful as a starting point in understanding the education and training review process, the use of the terminology is confusing. Although the FIPT charter indicates that "Competencies" should be developed/reviewed, career fields/paths develop Learning Outcomes (LOs), duties and tasks, and the like instead of competencies, hence our recommendation.

*Recommendation 3:* Define requirements carefully up front, and rigorously follow systems engineering processes. Our process, like so many programs' processes, suffered from requirements changes along the way. For example, we started out with a goal to create duties and tasks, the requirement changed to develop Performance Objectives, and the group finally settled on LOs. One example where we could have used stronger systems engineering processes was in configuration management—specifically tracking decisions made throughout the review process. Agendas and follow-up minutes are always developed for the SPRDE/SE FIPT, but perhaps this practice would be useful for the smaller meetings as well. Our experience indicated that decisions made at one meeting that necessitated follow-up actions were sometimes negated in future meetings. Another example relates to the configuration control of the review documents. The education and training review was a collaborative effort with participation from many people and organizations. Given the number of people and organizations editing documents, we may need to use more sophisticated ways of tracking documents' versions and configuration. Perhaps we could make better use of the SE CoP workspace provided to the group by DAU for this purpose.

# I. INTRODUCTION

In FY2004, the Systems Engineering office asked the Institute for Defense Analyses (IDA) to conduct a review of the systems engineering-related education and training offered by the Defense Acquisition University (DAU), and to determine ways that it could be revised or updated to achieve better implementation of systems engineering in acquisition programs. The DAU education and training resources are periodically reviewed to ensure that they are meeting the needs of their students and DoD the acquisition community. At the time of this review, many activities were occurring to revitalize systems engineering within the Department of Defense (DoD), including the development of new systems engineering policy.

The purpose of this paper is to document IDA's participation in the review, particularly of the Systems, Planning, Research, Development and Engineering/Systems Engineering (SPRDE/SE) career path. The first chapter provides a background for the review, summarizing recent changes to the DoD acquisition policy, including the systems engineering revitalization efforts. Chapter II then describes the Defense Acquisition Workforce Improvement Act (DAWIA) process which is the context for the education and training reviews, and provides an overview of how IDA worked within that process. Subsequent chapters describe the implementation of the review, as illustrated in Figure I-1. Chapter III discusses changes made to SPRDE/SE career path requirements, Chapter IV covers modification and review of the SPRDE/SE training materials, and Chapter V describes the process of developing SPRDE/SE "competencies," in the form of duties and tasks as a guide for SPRDE/SE certification course content. Each of these three chapters documents the education and training requirements/courses/competencies before the review as well as the recommended changes resulting from the review. The paper concludes with next steps and recommendations presented in Chapter VI and is followed by several appendixes containing supporting information. The last appendix, P, lists and defines acronyms used in the report.

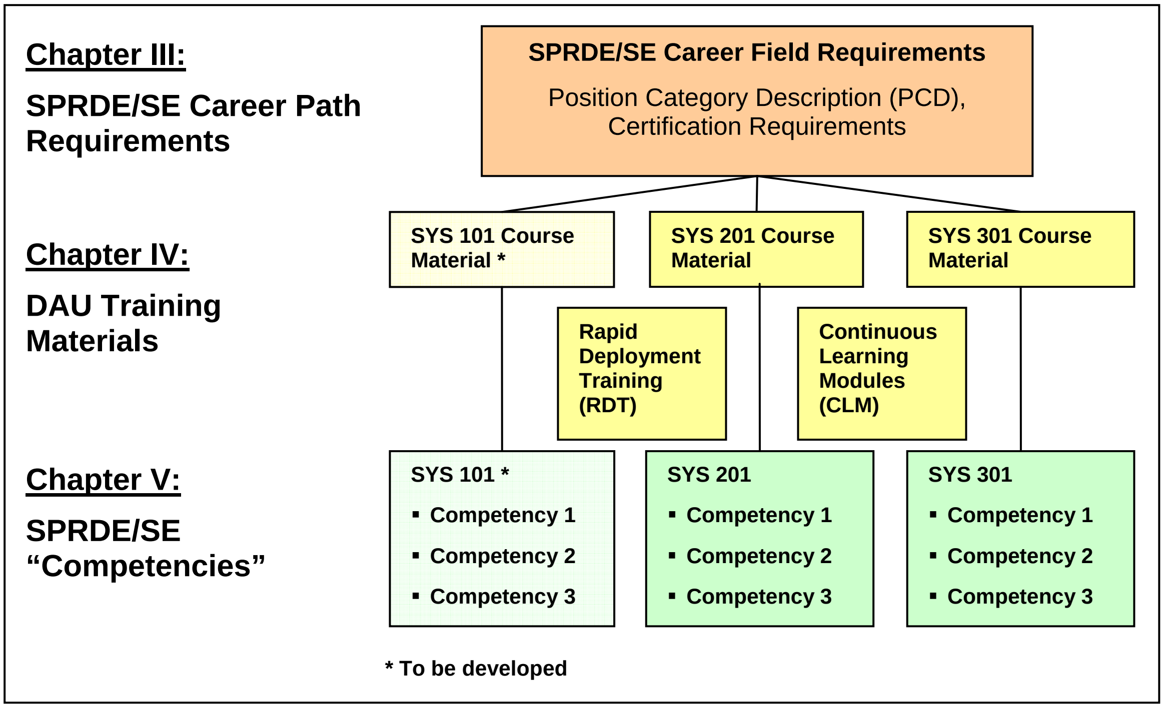


**Figure I-1. Structure of the Paper**

## A. DEPARTMENT OF DEFENSE POLICY CHANGES

At the time of this review, DoD was in the midst of a department-wide "transformation" into a more adaptive, capabilities-based organization. In the Transformation Planning Guidance, Secretary Rumsfeld described the outcome of the transformation as "fundamentally joint, network-centric, distributed forces capable of rapid decision superiority and massed effects across the battlespace."[1]

There are three parts to DoD's overall strategy for transformation:[2]

1) Transformed culture through innovative leadership

2) Transformed Processes—Risk adjudication using future operating concepts

- — Balance current requirements with future requirements
- — Reformed Capabilities-identification process: Joint Capabilities Integration and Development System (JCIDS)
- — Transformed strategic analysis

[1] DoD Transformation Guidance, April 2003, p.1

[2] Ibid., p. 8

3) Transformed Capabilities through force transformation

— Strengthening joint operations
— Exploiting US intelligence advances
— Experimenting with new warfighting concepts
— Developing transformational capabilities

The Transformation process is changing "the way we fight, the way we do business within the Department and the way we work with our interagency and multinational partners."[3] Key to changing the way DoD does business is reforming the acquisition process. Transformation seeks to shorten the acquisition cycle time and use a new "resource allocation process built around joint operating concepts" by linking acquisition strategies to future joint concepts.[4] The next two sections of this chapter discuss these topics in further detail.

### 1. Department of Defense 5000 Acquisition Series

The DoD 5000 Series documents, DoD Directive (DoDD) 5000.1 and DoD Instruction (DoDI) 5000.2, were updated in May 2003. The Regulation, DoD 5000.2-R, was canceled and will be replaced by the *Acquisition Guide*, one chapter of which is devoted to systems engineering. According to the DoD 5000 Resource Web site, the new version of the DoD 5000 series documents differ from the old one in that the new series—

- Encourages innovation and flexibility
- Permits greater judgment in the employment of acquisition principles
- Focuses on outcomes vice processes
- Empowers program managers to use the acquisition system vice being hampered by over-regulation [5]

A Dayton Aerospace paper summarized more specific changes to the 5000 series.[6] One is that evolutionary acquisition and spiral development are the preferred approaches to system development. Both of these are systems engineering models. The 2003 DoD 5000 also introduces the new Joint Capabilities Integration Development System, which

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3 Ibid., p. 6

4 Ibid., p. 7

5 DoD 5000 Resource Web site, Tutorial, http://dod5000.dau.mil/Tutorial/index.htm (accessed 16 August 2004)

6 "New" DoD 5000 Series Implications, Executive Summary, http://www.daytonaero.com/documents/5000_Series_Implications_5-20-03.pdf (accessed 16 August 2004) p. 1

replaces the old Requirements Generation System. JCIDS, as it is called, is described in more detail in the next section. Changes to the acquisition phases include the following:

- Concept Refinement and Technology Development are now two distinct phases
- Milestone A is now at the end of Concept Refinement
- A Design Readiness Review is required to enter the System Demonstration phase
- Milestone A is required to enter Technology Development

The preference for spiral development and evolutionary acquisition, in particular, is a good example to illustrate the importance of systems engineering education. These models are not widely understood in the community. The topics should be covered carefully in systems engineering education and training materials to ensure that the acquisition workforce has the background it needs to understand whether these approaches are the right ones for their particular systems/programs and to provide the systems engineers with background they need to employ these approaches.

### 2. Chairman of the Joint Chiefs of Staff 3170.01 Instruction and Manual

DoD Systems Engineers now must think in terms of “capabilities” rather than requirements. Understanding the requirements (or capabilities, as the case may be) has long been considered one of the most important parts of systems engineering. The new Joint Capabilities Integration and Development System (JCIDS) is using good systems engineering approaches early in the acquisition cycle, to provide joint, integrated solutions (materiel and non-materiel) to the warfighter. The Chairman of the Joint Chiefs of Staff (CJCS) 3170.01 Instruction and Manual describes the policies, procedures, and guidelines of JCIDS. Using joint concepts and integrated architectures, JCIDS identifies and prioritizes capability gaps and solutions to fill those gaps. Through this process, DoD intends to eliminate redundancy in new capability development.

There are three main analyses performed in JCIDS: the Functional Area Analysis (FAA), the Functional Needs Analysis (FNA), and the Functional Solution Analysis (FSA). The FAA identifies operational tasks, conditions and standards needed to achieve military objectives. The FNA then assesses the capability of current, joint capabilities to accomplish the tasks identified in the FAA. Resulting from the FNA is a list of capability gaps and redundancies, along with timeframes when the gaps need to be filled. Finally,

the FSA is an assessment of all potential Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities (DOTMLPF) approaches to address the gaps.[7]

Several new documents are required as a part of the JCIDS process. These documents are summarized below.[8]

- Initial Capabilities Document (ICD)— replaces a Mission Needs Statement (MNS)
  - Identifies a capability gap
  - Describes evaluation of DOTMLFP approaches
  - Supports the Analysis of Alternatives (AoA) in Concept Refinement
  - Not updated once approved
- Capability Development Document (CDD)—replaces the Operational Requirements Document (ORD) at Milestone B
  - CDDs are system specific and apply to a single increment of an evolutionary acquisition approach
  - Results from Technology Development phase of the acquisition cycle
  - Updated for subsequent increments
- Capability Production Document (CPD)—replaces the ORD at Milestone C
  - Identifies production attributes for a single increment of a program
  - Prepared during System Development and Demonstration (SDD)
  - Rewritten for each increment in an evolutionary program.
- Capstone Requirements Document (CRD)—unchanged from the Requirements Generation system
  - Describes overarching thresholds/goals and standards in functional areas
  - Developed only at Joint Requirements Oversight Council (JROC) direction.

The CRD will eventually be replaced by integrated architectures as they are developed and implemented.

## B. SYSTEMS ENGINEERING POLICY CHANGES

Amidst the overall Transformation in DoD, Systems Engineering Revitalization efforts were taking place in the Systems Engineering office. The Honorable Michael Wynne, Acting Under Secretary of Defense for Acquisition, Technology and Logistics

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7 CJCSM 3170.01A, 12 March 2003, p. A-1

8 Descriptions of the JCIDS documentation is taken from DAU's "DoD Business Transformation" briefing, http://dod5000.dau.mil/DOCS/257,1,DoD Business Transformation Meeting the Security Challenges of the 21ST century (accessed 26 August 2004)

(USD (AT&L)), and Dr. Glenn Lamartin, Director of Defense Systems, both issued policy memorandums: Mr. Wynne's memo focused on systems engineering policy, and Dr. Lamartin's on SEP guidance. Meanwhile, the Enterprise Development office developed vee-like[9] process models to help explain how systems engineering should be applied throughout the acquisition cycle and compiled the Systems Engineering chapter (Chapter 4) of the *Acquisition Guidebook.*

### 1. Systems Engineering Policy Memorandum

Mr. Wynne issued new systems engineering policy in a memorandum titled "Policy for Systems Engineering in DoD" to help "drive good systems engineering processes and practice back into the way we do business"[10] Signed on 20 February 2004, the memo established policy that took effect immediately and that was to be included in the next DoD 5000 series acquisition documents. The new systems engineering policy is as follows:

> Systems Engineering (SE). All programs responding to a capabilities or requirements document, regardless of acquisition category, shall apply a robust SE approach that balances total system performance and total ownership costs with the family of systems, systems-of-systems context. Programs shall develop a Systems Engineering Plan (SEP) for Milestone Decision Authority (MDA) approval in conjunction with each Milestone review, and integrated with the Acquisition Strategy. This plan shall describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It shall also detail the timing, conduct and success criteria of technical reviews. [11]

The memo lays out responsibilities for the Director of Defense Systems to support the policy—one of which is to "identify the requirement for a SEP in DODI 5000.2," and to provide specific, yet tailorable, guidance on that SEP in the *Acquisition Guidebook.* The Director of Defense Systems also shall review and provide recommendations regarding each program's SEP (for those programs where Mr. Wynne is the MDA in preparation for Defense Acquisition Board (DAB) Milestone Reviews and other acquisition reviews). A third responsibility is to establish a senior-level SE forum to help institutionalize systems engineering discipline in DoD. The responsibility most directly

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9 Information about the vee model is available at http://acc.dau.mil/simplify/ev_en.php?ID=6260_201&ID2=DO_TOPIC

10 Memorandum from Michael Wynne, "Policy for Systems Engineering in DoD," issued 20 February 2004

11 Ibid.

related to the education and training review documented in this paper is that the Director of Defense Systems shall "assess the adequacy of current Department-level, Systems Engineering related policies, processes, practices, guidance, tools, and ***education and training***." Mr. Wynne's memo is included in Appendix A of this paper.

### 2. Lamartin Systems Engineering Plan Memo and Guidance

In response to the policy issued by the acting USD ( AT&L), Dr. Lamartin, the Director of Defense Systems, issued interim guidance about the SEP in a memorandum titled, "Implementing Systems Engineering Plans in DoD—Interim Guidance." It was signed and released on 30 March 2004. The memo states that the SEP "is intended to be a living document, tailored to the program, and a roadmap that supports program management by defining comprehensive systems engineering activities, addressing both government and technical activities and responsibilities."[12] There is no set format for the SEP, but the memo highlights the following areas that the plan must address:[13]

- Systems engineering processes to be applied to the program
- System's technical baseline approach
- Event driven timing, conduct, success criteria and expected products of technical reviews
- Integration of systems engineering into the program's integrated product teams (IPTs)

The SE Office included some additional SEP guidance in the systems engineering chapter of the Acquisition Guidebook and is currently creating more detailed guidance including a proposed SEP outline. Dr. Lamartin's memorandum is attached in Appendix B.

### 3. Systems Engineering Revitalization "Hooks" and Policy

With the revitalization of systems engineering, the Enterprise Development office developed new ideas for guidance, which it referred to as "hooks." The hooks represent the office's current thinking on where systems engineering needs to go and may indicate the direction for new guidance coming out. Not all of these hooks are currently policy, although many are, such as the requirement for a SEP. The hooks are the following—

- Develop a systems engineering strategy

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12 Dr. Glenn Lamartin, "Implementing Systems Engineering Plans in DoD—Interim Guidance," Memorandum, 30, March 2004

13 Ibid.

- Address systems engineering (all acquisition phases, not just SDD) up front and early
- Consider systems engineering in total life cycle systems management
- Emphasize in-service systems engineering
- Ensure that systems engineering spans IPT (not located in an “SE IPT”)
- Acquisition components must maintain a robust systems engineering organization
- Ensure that lead engineer is jointly accountable to Program Manager (PM) and functional leadership
- Assign a lead systems engineer at program inception
- Establish a SEP early in the program definition and update it continuously as the program matures, through system operations and support
- Include in the SEP description of systems integration on the program IPTs, including resources, staffing, management metrics, and integration mechanisms
- Form a team of independent subject matter experts (SMEs) and program team representatives to conduct systems engineering technical reviews
- Ensure that systems engineering technical reviews are chaired by an independent technical authority
- Contractual documents address and require systems engineering technical reviews
- Tailor technical reviews in conjunction with the systems engineering processes to fit the acquisition strategy
- Approve technical baselines at technical reviews
- Ensure that technical reviews are event driven vs. schedule driven
- Develop and use metrics in technical reviews
- Evaluate the system’s technical basis for cost
- Develop and maintain requirements in an integrated framework

These hooks are not published, and the list is evolving. The list shown above was created based on discussions with the Enterprise Development office. We used this list to support our review.

### 4. Integrated Defense Acquisition, Technology and Logistics Life Cycle Management Framework

In an effort to provide the acquisition community with more direction on how to conduct systems engineering in the DoD acquisition phases, the Office of Enterprise Development created systems engineering “Vee” process models corresponding to the acquisition phases (e.g., Concept Refinement, Technology Development). Although these models for each phase are in the shape of a traditional “Vee” model, they differ in their

use of processes within the model. As a result, we call them “process-vees” throughout this paper. During the development of these process-vees, DAU was in the midst of revising a wall chart reference and teaching tool titled “Integrated Defense (AT&L) Life Cycle Management Framework.” DAU develops such wall charts periodically as a classroom aid for DAU students. After seeing an early version of the wall chart, the Enterprise Development Office saw the chart as a potential vehicle to communicate and teach the process-vee models and requested that DAU incorporate them. DAU agreed and the wall chart now includes the models mapped to the DoD 5000 acquisition phases. The Integrated Defense AT&L Lifecycle Management Framework also shows other information such as the inputs and outputs of each of the acquisition phases and the timing of technical reviews with respect to the process-vee models.

### 5. Acquisition Guidebook

The Enterprise Development office also coordinated the development of the Systems Engineering chapter (Chapter 4) of the *Acquisition Guidebook.*[14] The Systems Engineering chapter of the *Guidebook* includes the following sections:

- Systems Engineering in DoD Acquisition
- Systems Engineering Processes: How Systems Engineering Is Implemented
- Key Systems Engineering Activities in the System Life Cycle
- Systems Engineering Decisions: Important Design Considerations
- Systems Engineering Execution: Key Systems Engineering Tools and Techniques
- Systems Engineering Resources

The chapter begins with a section titled “Systems Engineering in DoD Acquisition Systems,” which describes how systems engineering is related to DoD acquisition. The next section, “Systems Engineering Processes: How Systems Engineering Is Implemented,” summarizes the systems engineering technical management processes and technical processes and the use of systems engineering standards and models. “Key Systems Engineering Activities in the Systems Life Cycle” then explains how the process-vees from the Defense Acquisition Framework fit into the DoD acquisition cycle, including descriptions and timing (event-based) of technical reviews. “Systems Engineering Decisions: Important Design Considerations” includes a list of important design considerations that systems engineers must take into account to develop an integrated set of requirements. Tools, such as the SEP, required and

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[14] The Guidebook is available at http://akss.dau.mil/DAG/ (accessed 1 December 2004)

elaborated upon by the Wynne and Lamartin memos, are described in “Systems Engineering Execution: Key Systems Engineering Tools and Techniques.” Finally, “Systems Engineering Resources” includes links to systems engineering reference materials from DoD, academia, and industry.

# II. SPRDE/SE REVIEW CONTEXT AND PROCESS

IDA conducted its review of systems engineering-related education and training within the context of the Defense Acquisition Workforce Improvement Act (DAWIA) designated career fields/paths and the general process by which these career fields/paths are managed. This chapter describes IDA's review of DAU's systems engineering-related education and training material in conjunction with the activities of the SPRDE/SE Functional Integrated Product Team (FIPT).

## A. DEFENSE ACQUISITION WORKFORCE IMPROVEMENT ACT

The DAWIA was signed into law in November 1991 after reviews of the DoD acquisition workforce found it to be "undertrained, underpaid, and inexperienced." DAWIA was enacted through an FY 1991 Defense Authorization Bill in order to bring more professionalism to acquisition personnel.[15] The act required the Secretary of Defense, acting through the Under Secretary of Defense (Acquisition, Technology, and Logistics), to establish education, training and experience requirements for the civilian and military acquisition workforce. These requirements are documented in DoD 5000.52-M, "Career Development Program for Acquisition Personnel."[16] DoD 5000.52-M states that the requirements will lead to improvements in the workforce by: [17]

a. Developing, on a long-term basis, a highly qualified diverse workforce capable of performing current and future DoD acquisition functions.

b. Meeting current and future DoD needs for acquisition personnel and providing capable replacements for senior acquisition positions on a planned and systematic basis.

c. Increasing the proficiency of DoD acquisition personnel in their present positions and providing guidance and opportunities for broadening experiences and progression commensurate with their abilities

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15 "The Defense Acquisition University From Consortium to Consolidation," Program Manager, May 2001, Kelly Berta, http://www.findarticles.com/p/articles/mi_m0KAA/is_3_30/ai_78399311 (accessed 10 August 2004), p. 1

16 DAU's Acquisition Community Connection Web site: http://acc.dau.mil/simplify/ev.php?ID=10106_201&ID2=DO_TOPIC (accessed 15 September 2004)

17 Website where 5000.52-M is available (accessed 10 August 2004), p.I-1.

d. Ensuring the effective use of training and education resources

The act also mandated the establishment of a Defense Acquisition University to coordinate the education and training of the workforce.[18] DAU and its relationship to DAWIA is described further in section B of this chapter.

### 1. Defense Acquisition Workforce Improvement Act Functional Areas and Career Fields/Paths

DAWIA identified 12 acquisition career fields in the acquisition workforce for which education, training, and experience requirements were described in 5000.52-M. "Career field" is defined as "one or more occupations that require similar knowledge and skills." Career fields may also encompass separate "career paths." For example, the SPRDE career field has two career paths: Science and Technology Manager (STM) and Systems Engineering (SE). Career fields and any paths they encompass are referred to generally as "career fields/paths" throughout this paper. A recent list of the DAWIA career fields (and career paths for SPRDE) is shown in the second column of Table II-1. These fields (and associated career paths) have changed some since DAWIA's inception. The first column of the table shows the functional area in which the career field (and career paths for SPRDE) fits. A Functional Advisor oversees the management of those career fields or paths within his or her functional areas.

### 2. Managing the Defense Acquisition Workforce Improvement Act Career Paths: Functional Area Charter

Each of the functional areas listed in the first column of Table II-1 is managed by a Functional Advisor. FAs are senior-level acquisition executives with expertise in that particular area. An Executive Secretary assists the FA in managing the career fields/paths and designates a Functional Integrated Product Team (FIPT). The Executive Secretary and FIPT work together to ensure that courses are up to date and relevant to the needs of the workforce. Taken from guidance in the SPRDE/SE Functional Area Charter, the following bullets describe the responsibilities of the FA and FIPT: [19]

- Establish and review the DoD criteria for designating Position Category Description(s) (PCD) and career path certification standards
- Annually certify experience, education, and training standards and position category descriptions as current, complete, and accurate

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18 Berta, p. 1

19 FIPT Charter from AnnMarie Choepel's minutes of the 11 December SRPDE FIPT meeting, Charter slide

**Table II-1. DAWIA Functional Areas and Career Fields/Paths**

| Functional Area | Career Fields/Paths |
|---|---|
| Acquisition Management | Program Management |
| Auditing | Auditing |
| Business, Cost Estimating, and Financial Management (BCEFM) | BCEFM |
| Facilities Engineering | Facilities Engineering |
| Information Technology | Information Technology |
| Logistics | Life Cycle Logistics |
| Procurement & Contracting/ Government Property | Industrial/Contract Property Management |
| | Contracting |
| | Purchasing |
| Science and Technology | Systems Planning, Research, Development and Engineering (SPRDE)/Science and Technology Manager (STM) |
| Technical Management | Production, Quality and Manufacturing (PQM) |
| | Systems Planning, Research, Development and Engineering (SPRDE)/Systems Engineering (SE) |
| | Test and Evaluation (T&E) |

Source: FAs and Career Fields were taken from DAU 2004 Catalog, pp. 5 and 19 http://www.dau.mil/catalog/default.aspx (accessed 10 August 2004). Matchup between the FAs and career paths was assisted by the LMI Report http://gravity.lmi.org/futurewf/ (accessed 10 August 2004) section 5, p. 18

- Annually certify content and quality of DAU courses as current, technically accurate, and consistent with DoD acquisition policies
- Recommend initiatives for career development and rotational assignments between various DoD Components as well as with other Government Agencies
- Promote and enable multifunctional career paths and make recommendations to augment existing career paths
- Oversee education and training requirements:
  - Identify competencies, allocations, quotas, student attendance, course critiques, priorities, funding, and reports under DoDI 5000.58
  - Make recommendations on the modifications, establishment or disestablishment of mandatory courses
  - Consider continuous learning needs and resources as part of the FA's requirements review process
  - Assist the DAU program Director and Course Director(s) as necessary with routine updates to the content of established courses to maintain currency

- Monitor and evaluate the effective implementation of DoD 5000.52-M within the functional area

The FIPTs commence meetings periodically to conduct the activities stated in the charter above. When a career field/path's FIPT proposes modifications to the career field/path elements, those modifications are submitted through the Functional Advisor to the Career Management Overarching Integrated Product Team (CMOAIPT). Depending on the nature of the modification, the CMOAIPT either makes recommendations to the DAU president or to the Director Acquisition Education, Training and Career Development (AET&CD). Recommendations regarding requirements for new courses or major changes to existing courses are provided to the DAU president, while recommendations about career paths, experience, education, and training standards are sent to the Director, AET&CD.[20]

## B. DEFENSE ACQUISITION UNIVERSITY

The Defense Acquisition University (DAU) develops all of the DAWIA career field and career path certification courses as well as other defense acquisition-related resources covering a variety of topics. DAU representatives work closely with the career field/path FIPTs in their development and modification of course material. Before launching into a more specific discussion about how the SPRDE/SE FIPT has worked with DAU, an introduction to some of DAU's instructional systems development terminology will be helpful, as these terms are used throughout this document.

### 1. Instructional Terminology

DAU representatives provided the Instructional Systems Development Terminology in Table II-2.

[20] "Functional Advisers 'Quarterback' Career Development, *ARToday*, Vol. 6, No. 3, June/July 2001, p. 1

**Table II-2. Instructional Systems Development Terminology from DAU**

| **Term** | **Defined as…** | **Example** |
|---|---|---|
| Competency | A behavior or set of behaviors that describes excellent performance in particular work contexts. Competencies are those worthy accomplishments that make the employee valuable to the employer and that make the employer valuable to the customer.<br><br>Historically the Department of Defense, when referring to training its acquisition workforce applied the term "competency-based" in attempting to determine training and education requirements. Competency-based training and education was viewed as job or occupation specific. That is, an individual learner would concentrate on mastering the "competencies" associated with a particular government job series or classification (e.g., Contract Specialist). | Complete appropriate DoD forms |
| Performance Outcomes | A statement of performance of what the student should be able to do, related to actual job performance requirements along with the conditions under which the student is to perform and the criteria for acceptable performance | Complete DoD 1351-2 within 5 days of returning from a Temporary Duty assignment |
| Learning Outcomes | For every education or training program, and for each course and lesson within that program, there is a set of intended learning outcomes. These outcomes are statements of what the learners should be able to do as a result of the instruction. The outcomes expected from a course or lessons are known as learning objectives, and serve three most important functions. Learning objectives:<br>• Define the desired outcomes of learning<br>• Serve as a guide to the selection of strategies and methods of instruction<br>• Provide criteria for evaluation of the learning | |
| Terminal Learning Objectives (TLO) | The identified desired learning outcomes after a segment of instruction, generally a course or a lesson or module. TLOs are frequently translated directly from task statements and clearly state the after-instruction performance the learner must be able to demonstrate. They must be observable and/or measurable and contain a condition, performance and standard. | Given a blank DoD 1351-2 form and all receipts, accurately complete the form so that the traveler will be reimbursed for all entitlement expenses. |
| Enabling Learning Objectives (ELO) | Provides the means for reaching the terminal objectives and generally consist of the skills, knowledge, and task steps that must be completed or satisfied in order to master the terminal objective. Enabling objectives are derived from the elements, skill, and knowledge requirements. | Describe the required information needed in the travel voucher.<br><br>Recognize reimbursable entitlement expenses. |

## 2. Performance Learning Model

In addition to the DAWIA certification courses, DAU also offers other educational resources to complement career field/path requirements. These resources are available to the acquisition workforce anytime and anywhere. DAU's Performance Learning Model, as it's called, "lays the foundation for meeting the career-long training and professional development needs of the AT&L workforce." [21] Figure II-1 shows a picture of this model from the 2004 DAU Course Catalog.

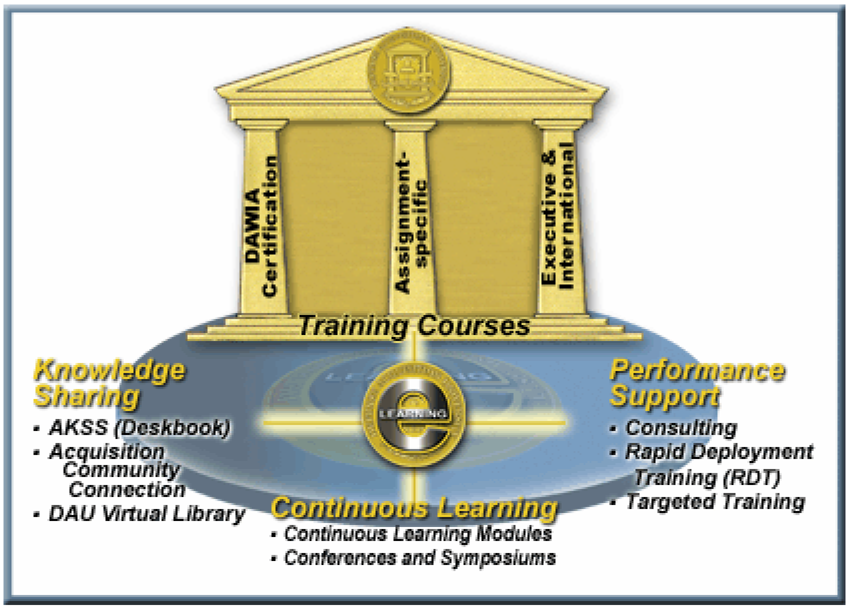


**Figure II-1. AT&L Performance Learning Model**

Knowledge Sharing, Continuous Learning, and Performance Support constitute the foundation of the DAU Performance Learning Model. Performance support "is tailored to the customer's needs and includes, but is not limited to, consulting, coaching, mentoring, and facilitation."[22] Included within Performance Support is Rapid Deployment Training (RDT)—an approach to quickly deliver training on a particular topic. DAU can focus on high-value initiatives to quickly develop and deliver training to the acquisition workforce right after the initiative is implemented, while updates are being made to certification courses. [23] Recent examples of RDT programs include DoD5000, Corrosion Prevention and JCIDS 3170.01c.[24]

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21 DAU Course Catalog 2004, p. viii

22 Ibid.

23 Ibid.

24 These programs can be accessed at http://view.dau.mil/dauvideo/view/channel.jhtml?stationID=909876928.

Continuous Learning Modules (CLM) are self-paced modules and briefings that DAU develops and makes available to the Acquisition workforce through the DAU Web site.[25] Students in DAWIA career fields/paths are required to complete 80 hours of these Continuous Learning courses every 2 years. The courses are not specific to a career field/path but instead provide information on particular topics of interest to acquisition professionals.

DAU manages the Acquisition Community Connection, Communities of Practice, and AT&L Knowledge Sharing System (Deskbook) as a part of the Knowledge Sharing part of the Performance Model. These Web sites provide an electronic forum for the acquisition workforce to obtain reference materials, lessons learned, and best practices and to ask questions.

### 3. Relationship to Defense Acquisition Workforce Improvement Act Career Field/Path Functional Integrated Product Teams

DAU works closely with the DAWIA Career Field/Path FIPTs. As the developer of the DAWIA education and training materials, DAU must address the recommendations that a FIPT makes regarding those materials. The FIPT develops a set of competencies that individuals in a career field/path need to have and then provides it to DAU as guidance for course development. The term "competencies" is used loosely here: the FIPT guidance may be in the form of Performance Objectives, Learning Outcomes or some other high-level course guidance (such as Duties and Tasks) that DAU and the FIPT feel is appropriate. Using these "competencies," DAU then develops Terminal Learning Objectives (TLOs) and Enabling Learning Objectives (ELOs) for the certification courses. Course developers use the TLOs and ELOs as guidance in developing the courses. DAU also works with the FIPTs in the development of RDT and CLMs. After a FIPT recommends a new CLM, they generally provide a subject matter expert to work with DAU to develop the course.

## C. SPRDE/SE REVIEW PROCESS

The most important career field/path for systems engineering is the Systems Engineering career path of the Systems Planning, Research, Development and Engineering career field. Systems engineering material is taught in other fields/paths as well, but the SPRDE/SE career path is the primary focus of the review. Review of other

[25] DAU Continuous Learning Modules are available at http://clc.dau.mil/kc/no_login/portal.asp.

systems engineering-related material in other career fields/paths and courses is covered in Section VI.A, "Next Steps," at the end of this document.

### 1. SPRDE/SE Career Path

The SPRDE career field is the largest of the DAWIA career fields. It includes scientists and engineers, typically working in laboratories and program offices, performing such activities as identifying, establishing, organizing, or implementing acquisition engineering objectives and policies, or establishing specifications.[26] In addition to the SE career path, the SPRDE career field has a Science and Technology Management (STM) career path, which is managed by a separate FA and FIPT. We did not consider the SPRDE/STM career path education and training material as a part of this review, although its systems engineering-related content will eventually be reviewed separately by the SPRDE/SE FIPT, as described in Chapter VI.

SPRDE/SE falls under the DAWIA Technical Management functional area. The Director of Systems Engineering, Mr. Mark Schaeffer, is the Functional Advisor for the Technical Management functional area and the three career fields/paths within it: SPRDE/SE; Production, Quality, and Manufacturing (PQM); and Test and Evaluation (T&E). Mr. Robert Skalamera, Deputy Director of Enterprise Development, is the Executive Secretary of the SPRDE/SE FIPT. A listing of the SPRDE FIPT membership is shown in Table II-3, below. In addition to the actual FIPT members, the group invites others, such as the executive secretaries of other career field's or path's FIPTs, to participate in their meetings.

**Table II-3. SPRDE/SE FIPT Members**

| SPRDE/SE FIPT Members | Organization/Service |
|---|---|
| Brooks Bartholow | Army/AMC |
| R. Pillai | DCMA/OCT |
| Lt. Col Erica Robertson | SAF/AQRE |
| John Shaefer, Jr. | Navy/SSP |
| Bob Skalamera (FIPT Chair) | OUSD(AT&L)/DS/SE—Deputy Director, Enterprise Development |
| John Snoderly | DAU, SPRDE Program Director |

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26 DoDI 5000.28, "Defense Acquisition Workforce" (1992) p. 51, http://www.dau.mil/career/files/5000-58i.pdf (accessed 25 August 2004)

IDA’s participation in the SPRDE/SE FIPT began in December 2003. Since that time IDA has hosted and facilitated four of the SPRDE/SE FIPT meetings: 11 December 2003, 22 January 2004, 26 February 2004, and 1 July 2004. Additional meetings were held at DAU on 22 July and 26 August 2004.

## 2. Review Process

### a. December and January Functional Integrated Product Team Meetings

During the SPRDE/SE FIPT meetings on 11 December and 22 January, one of the main topics of discussion was devising an approach to review the SPRDE/SE education and training, as required by the SPRDE/SE FIPT charter. The group decided that they should review the PCDs; education, training and experience (ET&E) requirements; Performance Objectives (POs); and Terminal Learning Objectives (TLOs) for all of the DAWIA certification courses—even those outside the SPRDE/SE career path—that include systems engineering-related material. The review would be conducted by certification level, starting with the SPRDE/SE career path.

One of the DAU representatives at the meeting suggested that the first step should be to review the existing “competencies” for the courses. These competencies are the high-level guidance from which DAU develops more detailed TLOs and ELOs. IDA encouraged the FIPT to use a systems engineering approach and emphasized the need to examine the existing competencies against some logical criteria. IDA recommended first looking at what today’s SPRDE/SE workforce needs to do—given the current DoD environment, policy and initiatives. The next step would be to perform a gap analysis between what the SPRDE workforce needs to do and the existing SPRDE/SE competencies. If the systems engineering workforce is considered the “system” here, IDA proposed defining the functions that the workforce system must perform—a functional architecture of sorts. The FIPT agreed to this approach, and a DAU representative explained that another career field, BCEFM, followed a similar approach, developing the competencies in the form of “duties and tasks” that the SPRDE/SE workforce performs. DAU provided the BCEFM “Duties and Tasks” list to IDA as an example to follow. Note that the term “duties and tasks” does not exist in the ISD terminology table earlier in this chapter. DAU does not appear to have been consistent in its use of ISD terminology, so we were not overly concerned about these terms. Regardless of the terms used, the point was to provide DAU with requirements for what a student should learn/ be able to do at a given course level.

Ideally, IDA would have conducted a requirements analysis workshop to determine what the SPRDE/SE workforce needs to know and do. Early in our work, we consulted with another team in the Cost Analysis and Research Division of IDA that performed an assessment of the Program Manager (PM) courses for DAU. That IDA team interviewed the students who took the PM course, as well as some of their supervisors, 90–120 days after graduation, asking them about the relevance and effectiveness of the PM courses being assessed. Unfortunately, we were unable to pursue such activities for the SPRDE/SE review due to time constraints. Instead, we relied on the SPRDE/SE FIPT members to ensure that the functions/duties and tasks were accurate.

### b. Proposed IDA Overall Approach

During the 26 February FIPT, IDA proposed an approach to review the SPRDE education and training requirements, guidance, and materials using a combined top-down and bottom-up approach. Figure II-2, below, shows a depiction of that approach. It was approved by the SPRDE FIPT.

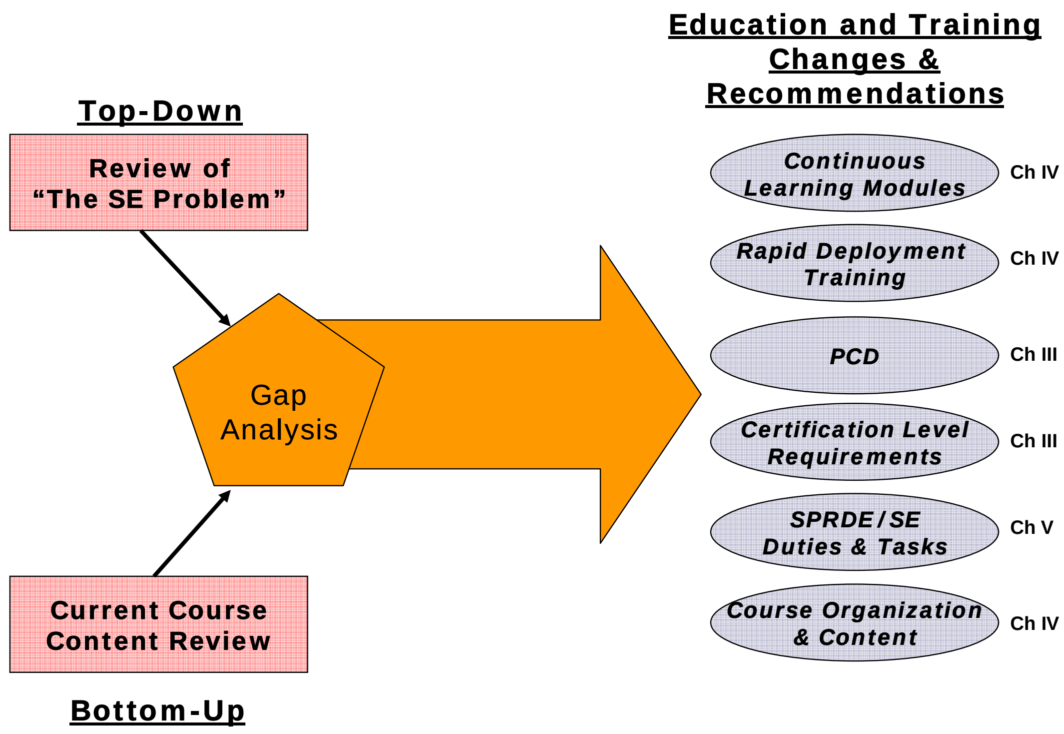


**Figure II-2. Overview of Proposed Approach to SPRDE/SE Course Review**

The idea behind the review was to merge a top-down and a bottom-up approach to support a gap analysis and generate recommendations to the FIPT regarding changes to the education and training elements of the SPRDE/SE career path. The top-down review, or review of "The SE Problem," would take into consideration DoD and systems engineering policy guidance, such as the "hooks," the systems engineering chapter of the *Acquisition Guidebook*, the Defense Acquisition Framework wallchart, and non-DoD best practice resources. The top-down review is described later, in Chapter V. The bottom-up review, on the other hand, would be conducted through a review of current SPRDE/SE certification course content (discussed in Chapter IV) and review of past and existing competencies/TLOs/ELOs for those certification courses (discussed in Chapter V). Looking at what exists in the courses compared with what should exist is the gap analysis. The ovals on the right side of the diagram are the SPRDE/SE education and training elements to be reviewed and revised through the process. Each of these ovals will be addressed in more detail in the chapters indicated in the figure.

A distinction should be drawn at this point regarding the implementation of this approach. IDA was specifically responsible for the development of the SPRDE/SE competencies in the form of "Duties and Tasks" that SPRDE/SE personnel perform. Modification of other elements, such as the Continuous Learning Modules, Rapid Deployment Training, and PCD and certification level requirements was done by the FIPT. The approach documented here, which IDA proposed and followed in developing the SPRDE/SE duties and tasks, was not necessarily followed by others in their parts of the review.

# III. SPRDE/SE CAREER PATH GUIDANCE DOCUMENTS

Two of the primary SPRDE career field guidance documents, the Position Category Description (PCD) and the Education, Training and Experience (ET&E) certification requirements, are described in this chapter. The SPRDE FIPT has proposed revisions to both the PCD and the certification requirements. These revisions were submitted to the Career Management Overarching Integrated Product Team (CMOAIPT) for approval. [27]

## A. POSITION CATEGORY DESCRIPTION

A PCD describes the acquisition duties that an individual working within a DAWIA career field/path is likely to perform. The descriptions are generally defined by these duties rather than specific job title or occupational series.

The SPRDE/SE PCD was as follows:

> Plan, organize, monitor, manage, oversee, and/or perform research and/or engineering activities relating to the design, development, fabrication, installation, modification, or analysis of systems or systems components. Duties may require identification, establishment, organization, or implementation of acquisition engineering objectives and policies, or establishing of specifications. Scientists and engineers directly supporting acquisition programs, projects, or activities (including medical) usually accomplish these duties.

The SPRDE/SE FIPT revised the PCD to stress integration, emphasize the entire life cycle, and reinforce the application of systems engineering to acquisition. The proposed revision reads as follows—

> Plan, organize, monitor, manage, oversee and/or perform research and/or engineering relating to the analysis, design, development, integration, verification and validation, modification, and sustainment and support of systems or system components across the entire system life cycle. Duties may require identification, integration, or implementation of acquisition engineering (systems engineering as applied to acquisition) objectives, policies, guidelines, and processes spanning both internal (acquirer) and external (supplier) domains. Scientists and engineers directly supporting

[27] From AnnMarie Choepel's minutes of the 26 February SPRDE FIPT meeting

acquisition programs, projects, or activities usually accomplish these duties.

## B. EDUCATION, TRAINING AND EXPERIENCE CERTIFICATION REQUIREMENTS

Certification requirements for the SPRDE/SE career path are shown in Table III-1. Three levels of certification are available, with education, experience, and training requirements for each as shown. The courses in the Training column are discussed further in Chapter IV.

**Table III-1. SPRDE/SE Certification Requirements**

| | **Education** | **Training** | **Experience** |
|---|---|---|---|
| Level I | Baccalaureate degree in engineering, physics, chemistry, mathematics, or a related field; or at least 10 years of acquisition experience in Systems Planning, Research, Development and Engineering (as of 1 October 1991) | ACQ 101 - *Fundamentals of Systems Acquisition Management* | 1 year of acquisition experience in science or engineering |
| Level II | Baccalaureate degree in engineering, physics, chemistry, mathematics, or a related field; or at least 10 years of acquisition experience in Systems Planning, Research, Development and Engineering (as of 1 October 1991)<br>(Desired) Master's degree in engineering, physics, chemistry, mathematics, operations research, management, or a related field<br>(Desired) 9 semester hours from among accounting, business finance, law, economics, industrial management, quantitative methods, or organization and management. (DANTES or CLEP exams may be substituted) | ACQ 201 *Intermediate Systems Acquisition*<br>SYS 201 *Intermediate Systems Planning, Research, Development and Engineering*<br>(Desired) A DAU Level 200 or Level 100 course mandatory for Acquisition Logistics; Program Management; Production, Quality and Manufacturing; Information Technology; or Test and Evaluation | 2 years of acquisition experience in science or engineering<br>(Desired) An additional 2 years of acquisition experience in science or engineering |
| Level III | Baccalaureate degree in engineering, physics, chemistry, mathematics, or a related field; or at least 10 years of acquisition experience in Systems Planning, Research, Development and Engineering (as of 1 October 1991)<br>(Desired) Advanced degree in engineering, physics, chemistry, mathematics, operations research, management or a related field<br>(Desired) 12 semester hours from among accounting, business finance, law, economics, industrial management, quantitative methods, or organization and management. (DANTES or CLEP exams may be substituted) | SYS 301 *Advanced Systems Planning, Research, Development and Engineering*<br>(Desired) Any mandatory DAU Level 200 or Level 300 course in Acquisition Logistics; Program Management; Manufacturing, Production, and Quality Assurance; Information Technology; or Test and Evaluation | 4 years of acquisition experience in science or engineering<br>(Desired) 4 additional years of experience in acquisition positions of increasing responsibility and complexity |

The SRPDE FIPT made one small revision to these requirements by adding "biology" as an acceptable degree for the SPRDE education requirements. The education requirement now reads:

> Baccalaureate degree in engineering, physics, chemistry, biology, mathematics, or a related field; or at least 10 years of acquisition experience in Systems Planning, Research, Development and Engineering (as of 1 October 1991)

Another change was made to the training requirements—the addition of a SYS 101 course to the level 1 certification requirements. Chapters IV and V talk more about this decision. After the training piece is more under control, the FIPT may wish to revisit the education and experience requirements again.

# IV. SPRDE/SE TRAINING RESOURCES

SPRDE/SE training resources include both the certification courses and other systems engineering-related materials developed by DAU, such as Continuous Learning Modules and Rapid Deployment Training. This chapter describes the existing and proposed training resources for the SPRDE/SE career path as well as content reviews IDA conducted on Systems Engineering (SYS) 201 A&B and SYS 301.

## A. SPRDE/SE CERTIFICATION COURSES

DAU develops DAWIA certification courses for the various career fields and paths using the following certification guidelines:[28]

- Level 1 courses are "designed to provide fundamental knowledge and establish primary qualification and expertise in the individual's career field, job series or functional area."
- Level 2 courses focus on "functional specialization" and are designed to "enhance the employee's capabilities in a primary specialty or functional area."
- Level 3 courses focus on "managing the acquisition process and learning the latest methods being implemented in the career field or functional area."

DAU's current (2004) course offerings in the SPRDE/SE career path are shown in Table III-1 in the previous chapter. They include ACQ 101 for Level I certification, ACQ 201A/ACQ 201B and SYS 201A/SYS201B for Level II certification, and SYS 301 for Level III certification. ACQ 201 A and SYS 201 A are on-line, distance learning components of their ACQ 201 B and SYS 201 B resident/on-site classroom-taught counterparts. The ACQ courses are general acquisition courses that form the basis for most acquisition career fields/paths. Unlike the SYS courses, which are fundamental to the SPRDE/SE career path, the ACQ courses do not relate to a single career field/path.

At the time of this review, SPRDE/SE level I certification did not include a SYS course. However, the FIPT was interested in developing one, and DAU was already considering its development. At the direction of Bob Skalamera, Deputy Director of Enterprise Development, IDA presented the SPRDE/SE Career Path and Certification

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28 DAU Course Catalog 2004, p. 11

Level model shown in Figure IV-1 as a part of its review approach presentation. In the proposed model, level I courses would teach the theoretical basis for systems engineering, covering systems engineering revitalization initiatives and knowing how to participate in systems engineering activities. The level II courses would teach what to do in each life cycle phase, including sustainment engineering. The level III course would cover systems engineering management and leadership capability, including knowing how to lead a review and perform the duties of chief engineer. The chart below, presented at the 26 February FIPT, shows different options to achieve the certification level goals. The options were based on whether or not the SPRDE/SE FIPT opted to develop a new SYS 101 course. The options were 1) stay with the status quo, 2) develop a new SYS 101 course for level I, and 3) split the SYS 201 A and B courses up between levels I and II.

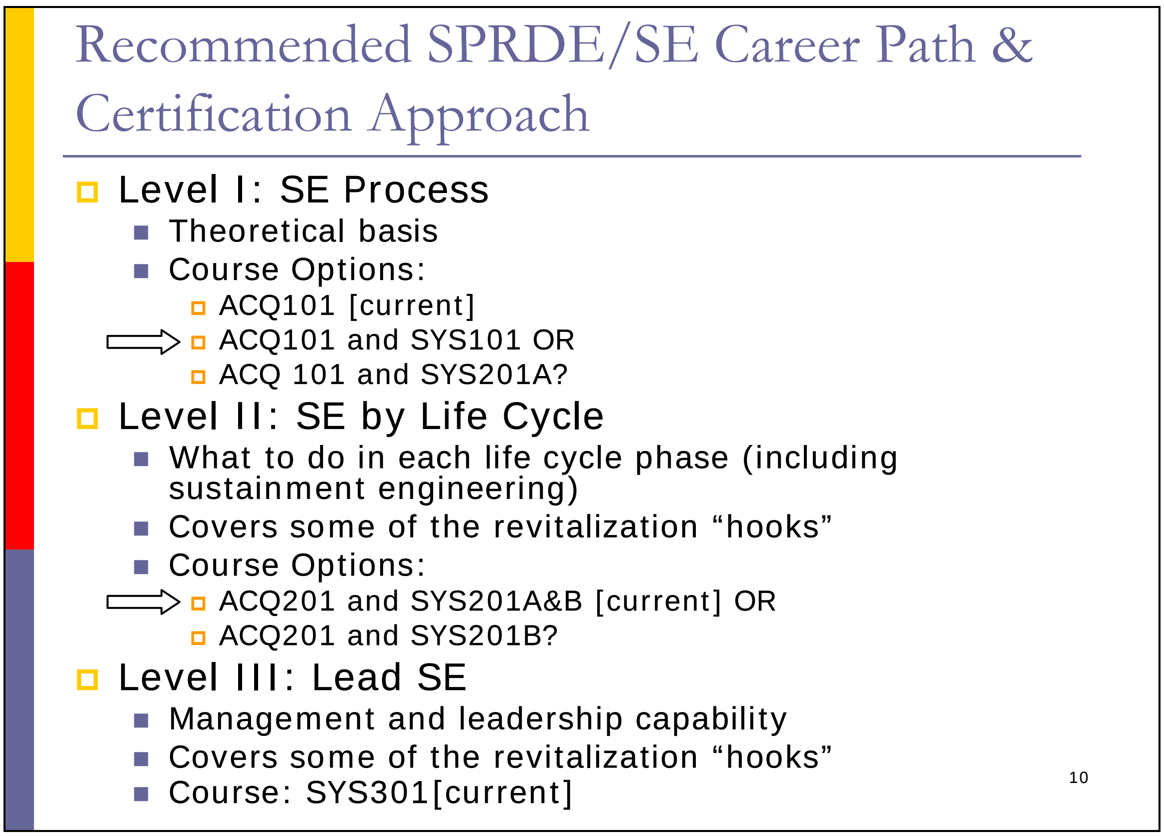


**Figure IV-1. Recommended SPRDE/SE Career Path and Certification Approach**

The SPRDE/SE FIPT did choose to develop the SYS 101 course; the chosen options on the graphic are marked with arrows. Much of the new course material resulting from changes to systems engineering policy and systems engineering revitalization “hooks” would be covered in the level II SYS course. For example, the

Defense Acquisition Framework (wall chart) resulted in a significant amount of new guidance about how systems engineering should be conducted throughout the acquisition phases. More basic, theoretical systems engineering process material that had originally been covered in the level II SYS 201A online course could now be moved into the level I course, SYS 101. However, because of a lag between enrollments of each of these courses, it is recognized that a clear division of subject matter across the three levels is not possible and there will necessarily be some overlap.

This next section includes the course descriptions, DAU course catalog narratives, and objectives for the courses required for SPRDE/SE certification.

### 1. Level 1

#### a. ACQ 101

The DAU description for ACQ 101:

- For military officers, O-1 through O-3, and DoD civilians, GS-5 through GS-9. However, the course is open to all ranks and grades
- Required for Level I certification in SPRDE/SE career path
- No prerequisites
- Distance Learning

The 2004 DAU course catalog narrative for the ACQ 101 course includes the following:

> This course provides a broad overview of the DoD systems acquisition process, covering all phases of acquisition. It introduces the requirements generation and resource allocation processes, the DoD 5000 Series documents governing the defense acquisition process, and current issues in system acquisition management. Designed for individuals who have little or no experience in DoD acquisition management, ACQ101 has proven very useful to personnel in headquarters, program management, and functional or support offices.

In addition, students who successfully completed the existing ACQ 101 course would be able to recognize—

- The fundamental precepts and bases of defense systems acquisition management
- The diverse, interrelated, and changing nature in the different disciplines of defense systems acquisition management
- The regulations and governing structures of defense systems acquisition management

### b. Proposed SYS 101

As discussed in the previous chapter, the addition of a SYS 101 course was desired among the DoD systems engineering community. DAU felt that this addition would be fairly straightforward because a lot of the material currently taught in the SYS 201A on-line course could be incorporated into a SYS 101 course.

## 2. Level 2

### a. ACQ 201A

The DAU description for ACQ 201A:

- For military officers, O-3 and above; civilians, GS-9 and above; and industry equivalents who are Level I certified in acquisition. Students should have 2 to 4 years of acquisition and/or logistics experience
- Required for Level II certification in SPRDE/SE career path
- Prerequisite ACQ 101
- Distance Learning

The 2004 DAU course catalog narrative for the ACQ 201A course:

> Intermediate Systems Acquisition, Part A, uses computer-based training to prepare mid-level acquisition professionals to work in integrated product teams by understanding systems acquisition principles and processes. Both ACQ201A and ACQ201B are required for DAWIA certification.

In addition, students who successfully completed the existing ACQ 201A course would be able to—

- Enhance their knowledge of the business, technical, and managerial aspects of acquisition;
- Understand and appreciate the critical role that each functional discipline plays in the acquisition process; and
- Using computer-based training, theoretically participate in simulated integrated product teams to develop plans and resolve problems

### b. ACQ 201B

The DAU description for ACQ 201B:

- For military officers, O-3 and above; civilians, GS-9 and above; and industry equivalents who are Level 1 certified in acquisition. Students should have 2 to 4 years of acquisition and/or logistics experience.
- Required for Level II certification in SPRDE/SE
- Prerequisite ACQ 201A
- Resident/on-site, 5 class days

The 2004 DAU course catalog narrative for the ACQ 201B course includes the following:

> Intermediate Systems Acquisition, Part B, prepares mid-level acquisition professionals to work effectively in integrated product teams by understanding systems acquisition principles and processes. Both ACQ201A and ACQ201B are required for DAWIA certification

In addition, students who successfully completed the existing ACQ 201B course would be able to—

- Enhance and apply their knowledge of the business, technical, and managerial aspects of acquisition;
- Understand and appreciate the critical role that each functional discipline plays in the acquisition process; and
- Effectively participate in integrated product teams and apply knowledge gained in ACQ201A to develop plans and resolve problems

**c. SYS 201A**

The DAU description for SYS 201A:

- Introductory, theoretical
- Required for Level II certification in SPRDE/SE career path
- Prerequisite ACQ 201B
- Distance learning

The 2004 DAU course catalog narrative for the SYS 201A course includes the following:

> This journeyman-level course exposes students to systems engineering and associated topics. Course content includes the systems engineering process; systems engineering planning; technology insertion; risk management; trade studies; configuration management; cost containment; technical reviews; and Environmental, Safety, and Occupational Health (ESOH).

In addition, students who successfully completed the existing SYS 201A course would be able to—

- Understand the systems engineering process
- Know the associated systems engineering technical activities
- Evaluate a Hazardous Material Management Plan and identify ESOH issues that need further clarification, and
- Develop and defend a technical review checklist

### d. SYS 201B

The DAU description for SYS 201B is—

- Practical
- Required for Level II certification in SPRDE/SE career path
- Prerequisite SYS 201A
- Five class days, resident on-site

The 2004 DAU course catalog narrative for the SYS 201B course includes the following:

> This journeyman-level course requires students to apply the Systems Planning, Research, Development and Engineering processes and techniques learned in SYS 201A. Students will work in integrated product teams to apply the systems engineering process and its associated technical activities.

In addition, students who successfully completed the SYS 201B course would be able to—

- Conduct a requirements analysis for a given need
- Prepare Functional Analysis and Allocation and Synthesis tools for a given scenario
- Apply the acquisition risk management process
- Propose trade study methodologies
- Develop technical performance measures

## 3. Level 3

### a. SYS 301

The DAU description for SYS 301:

- For DoD civilians, GS-13 and above, and military officers, O-3 to O-6, who are Level II certified in the SPRDE/SE career path. Equivalent industry acquisition managers are also eligible
- Prerequisite SYS 201
- 10 class days, resident on-site

The 2004 DAU course catalog narrative for the SYS 301 course is as follows:

> Designed for senior DoD acquisition personnel, this course emphasizes an understanding of science, technology, and the systems engineering processes throughout a system's life cycle by using relevant case studies and exercises involving all acquisition phases and milestones. Participants employ the proven principles and tools of systems engineering requirements analysis, risk management, technical performance measures,

tradeoff analyses, configuration and data management, and technical reviews. Advanced tools, such as integrated product teams, modeling and simulation, and open systems architectures, further facilitate managing and developing the system.

In addition, students who successfully completed the SYS 301 course would be able to—

- Analyze and solve senior-level technical problems
- Forecast cost, schedule, performance, and risk issues across the acquisition life cycle
- Integrate program office activities
- Manage technical obsolescence, advanced technology tools, and acquisition reform implementation

### 4. IDA Course Content Reviews

As a part of the bottom-up review of current SPRDE/SE education and training material, IDA reviewed the content of the SYS 201A and B and SYS 301 courses. We did not have specific criteria against which to review the courses, but conducting these reviews was a way to familiarize ourselves with the course material, ask questions, and make general suggestions, including highlighting those areas where the material needed to be updated. In addition to the general reviews, IDA also reviewed all three of these existing courses against the systems engineering revitalization "hooks." Both of these reviews were provided to the Enterprise Development office and to DAU. The reviews can be found in Appendixes C (SYS 201A and B), D (SYS 301), and E (SYS 201A and B and 301 reviewed by hook).

## B. ADDITIONAL SPRDE/SE RESOURCES

Even though the additional systems engineering resources that DAU develops, such as CLMs, are not tied to a specific career field/path, the DAWIA Functional Advisors and FIPTs are involved in their development.[29] Chapter II describes some of the resources DAU develops to complement DAWIA certification. This chapter documents recommendations that the SPRDE/SE FIPT made regarding these materials.

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[29] Although continuous learning modules are not currently required for certification in any of the career field/paths, specific CLMs may be recommended for a particular career path/field. The DAU Continuous Learning Center website has a capability that allows the user to search for CLMs recommended for a particular career field/path.

### 1. Continuous Learning Modules

Each of the Functional Areas is allotted approximately three CLMs each year. Technical Management's three modules for FY04 were ISO 9000, Reliability and Maintainability, and Joint and Multi-Test and Evaluation. After the SPRDE FIPT was allotted two additional CLMs for FY04, the group proposed several additional CLM topics, including Technical Reviews, System Safety Hazard Analysis, Cost Considerations in Systems Engineering, Systems Engineering for Program Success, Systems Engineering Planning, and Contracting for Systems Engineering. The SPRDE/SE FIPT prioritized the proposals at the 26 February meeting, after which Technical Reviews and System Safety Hazard Analyses were selected and scheduled for development in 2004. As the FY04 CLMs are being developed and finalized, proposals for the FY 05 SPRDE/SE allotment of CLMs are already being solicited. There are already several systems engineering-related CLMs, such as "Joint Capabilities Integration and Development System (JCIDS)," "Lean—Six Sigma, Evolutionary Acquisition (EA): the What & Why of EA," "Reliability and Maintainability," "Value Engineering," and "Introduction to Interoperability" to name a few.

### 2. Rapid Deployment Training

The SPRDE FIPT proposed using Rapid Deployment Training (RDT) to communicate to the acquisition workforce the new systems engineering policy and SEP guidance from Mr. Wynne's and Dr. Lamartin's memorandums. As the name indicates, RDT courses are intended to reach the acquisition community quickly. The DAU team indicated that roughly 45 days are needed to develop such an RDT course. Current RDT modules are available at http://www.dau.mil/performance_support/RDT.asp.

### 3. Systems Engineering Community of Practice (SECoP)

DAU manages a Systems Engineering Community of Practice, available at http://acc.dau.mil/simplify/ev_en.php. The SECoP is part of a larger community of practice that includes other acquisition-related subject areas such as Program Management and Contract Management. This website provides a general resource for systems engineering-related information. At one of the early FIPT meetings, DAU offered space on the CoP as workspace for the SPRDE/SE FIPT. The FIPT accepted the workspace and two of the SPRDE FIPT members were granted "editor" privileges to the SECoP.

### 4. Systems Engineering Resources and Top-down Approach

The foregoing additional SPRDE/SE resources are primarily driven by the top-down part of the review process, as shown in Figure IV-2. The top-down approach is a review of "The SE Problem" that takes into account the current acquisition environment (e.g., changes to DoD 5000), systems engineering-related policy changes, and special initiatives, such as safety. The CLMs and RDTs convey these special initiative topics and changes to policy using the CLMs or RDT—whichever is more appropriate for the situation.

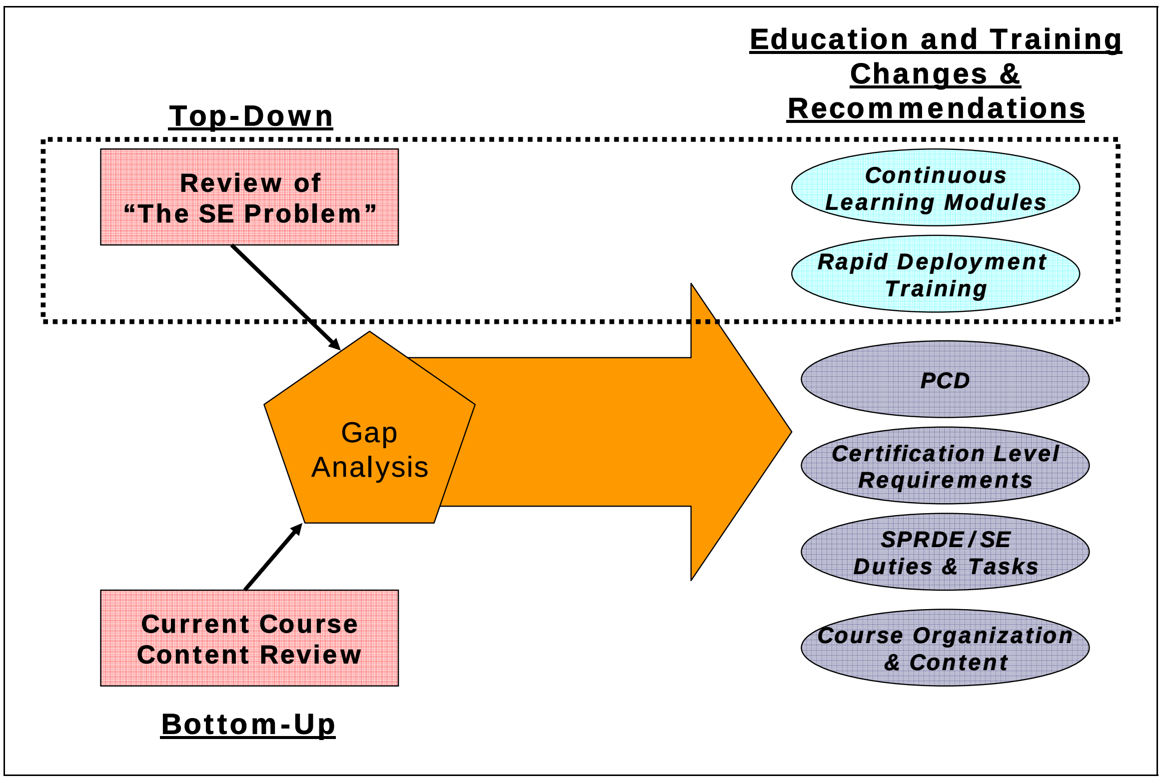


Figure IV-2. SE Resources and Top-down Approach

# V. SPRDE/SE COMPETENCIES

This chapter describes how IDA developed the SPRDE/SE competencies in the form of “duties and tasks” that the SPRDE/SE personnel must perform.

## A. IDA’S PROCESS FOR DEVELOPING SPRDE/SE DUTIES AND TASKS

As described in Chapter II, IDA proposed a process for reviewing SPRDE/SE education and training. As a part of this overall approach, IDA suggested a process for developing the SPRDE/SE Duties and Tasks. This included the following steps:

- Top-down Approach
  - Compiling and mapping lists of processes and activities from systems engineering standards, handbooks, and guides
  - Compiling recognized best practices or deficiencies in systems engineering implementation from various sources
  - Reviewing systems engineering policy and guidance
- Bottom-up Approach
  - Reviewing existing SPRDE course material
  - Reviewing existing and past SPRDE competencies, TLOs/ELOs, POs, etc.
- Combining these efforts in order to compile a list of SPRDE/SE Duties and Tasks
- Organizing SPRDE/SE duties and tasks into levels described in Chapter IV
  - Level 1: SE Processes
  - Level 2: SE by Life Cycle Phase
  - Level 3: Lead SE

Once the duties and tasks were developed, we envisioned that the SPRDE/SE FIPT would review them to ensure that they accurately reflected the needs of the SPRDE/SE workforce. Following the FIPT review, these duties and tasks would be provided to DAU as guidance from the FIPT for course content development. The first step in this process was to compile a list of sources for the review. These sources were presented to the FIPT at the 26 February meeting along with the overall review approach.

### 1. Resources for the Top-Down Review

In addition to the DoD and systems engineering policy, including the "hooks," IDA collected a list of other systems engineering resources to consult for the top-down review. These resources are listed here in two general categories: those that covered systems engineering processes and activities and those that document best practices and deficiencies.

On SE Processes and Activities

- International Council on Systems Engineering's (INCOSE) Systems Engineering Book of Knowledge (SEBoK) Competencies and Handbook
- Capability Maturity Model Integration (CMMI)-Systems Engineering/ Software Engineering/Integrated Product and Process Development (SE/SW/IPPD)
- Marine Corps System Command (MCSC) Engineering Certification Guidelines
- ISO/IEC 15288, *Systems Engineering—System Life Cycle Processes*
- EIA 632, *Processes for Engineering a System*
- IEEE 1220, *Application and Management of the Systems Engineering Process*
- Boeing Commercial Sources data base
- National Security Agency's (NSA) Systems Engineering Training program requirements
- IBM certification program requirements
- Other systems engineering certification program requirements (IDA research)
- Systems engineering college textbooks

On Best Practices and Deficiencies

- Logistic Management Institute (LMI) Future Acquisition and Technology Workforce Report
- Tri-Service Assessment Initiative analyses
- Government Accounting Office (GAO) Best Practices Reports
  - Strong Management, Processes, and Metrics Needed to Improve Software Acquisition
  - Defense Acquisition: Employing Best Practices Can Shape Better Weapon Systems Decisions
  - DoD Teaming Practices not Achieving Potential Results
  - A Constructive Test Approach is Key to Better Weapon System Outcomes
  - Software and Systems Process Improvement programs Vary in Use of Best Practices

- Defense Science Board (DSB) Reports
  - Task force on Defense Software
- Dayton Aerospace Quick Study Report on the Health of Systems Engineering Process Application

IDA presented the process and activities resources and the best practices and deficiencies in systems engineering resources to the FIPT and requested that the FIPT provide other additional sources that would be useful in the review. IDA compiled material from the process- and activity-related resources above into a large table of "Systems Engineering Topics." This table is broken up into segments and attached in Appendix F.

The FIPT recommended one additional source to the best practices and deficiencies resources--the Space Broad Area Review (Space BAR). IDA compiled the systems engineering recognized best practices and deficiencies from these resources into a table titled "Identified Systems Engineering Best Practices or Deficiencies," which is attached in Appendix G.

### 2. Reources for the Bottom-Up Review

Resources for the bottom-up review included material from the existing SPRDE/SE certification courses—SYS 201A & B and SYS 301—and IDA's content reviews of those courses. DAU also provided IDA with a number of additional sources to draw from. A list of these resources is shown below:

- ACQ 101, 201 A and B TLOs
- IDA's content reviews and reviews by "hooks" of SYS 201 A and B, and 301
- Course Student Assessment Plans (CSAPs) for SYS 201 A and B and 301
- "DAU's Systems Engineering Department Revamping SYS-301 Course," by Dr. Martin Falk (included in Appendix H)
- "SPRDE Curriculum Assessment," James Childress, Program Director SE and T&E, 18 December 2000
- SPRDE competencies from past years

Appendix K-2 of the LMI Workforce Report includes systems engineering-related competencies, so we also used these competencies in the bottom-up review (these competencies are included in this paper in Appendix I). Note that the LMI report is also listed under the top-down sources as well. The Future Acquisition and Technical Workforce Report, published in early 2000, contains certain assumptions (called "trends") upon which its list of competencies is based. Before using the LMI competencies, IDA wanted to validate, change, or eliminate those assumptions based on

the current environment to determine how to include the competencies in our SPRDE/SE Duties and Tasks list. We presented the LMI Workforce Report Assumptions to the SPRDE/SE FIPT and asked them to review the assumptions. Based on feedback from the SPRDE/SE FIPT, the assumptions were modified for 2004. The briefing IDA provided to the FIPT along with the FIPT's comments is included in Appendix J.

### 3. Emphasis on Environmental, Safety and Occupational Health

At the request of Mark Schaeffer, Director of Systems Engineering, IDA coordinated with Environmental, Safety, and Occupational Health (ESOH) subject matter experts to ensure that ESOH-related material was included in the competencies for the SPRDE/SE career path. Mr. Schaeffer is the chair of Acquisition and Technology for Safety on the Defense Safety Oversight Council (DSOC). His request for us to work with the ESOH SMEs came out of an initiative to revitalize the safety message by improving communication of the safety problem. ESOH does not have a career field/path or a Functional Advisor (although they have formed an ad hoc FIPT); thus, it is important that the ESOH material be covered in the existing career fields and paths. It was suggested that perhaps some ESOH material could be input to some of the existing case studies used in the SPRDE/SE curriculum. Other activities related to this revitalization include the System Safety CLM (through the SPRDE/SE FIPT), the Corrosion RDT, and the Corrosion CLM (developed by the National Association of Corrosion Engineers, or NACE).

IDA suggested that the ESOH SMEs develop a list of ESOH-related "Duties and Tasks" based on the BCEFM model, just as we were doing for SPRDE/SE in general. The ESOH SMEs attended our Duties and Tasks development meetings and provided us with a list of ESOH-related duties and tasks. We incorporated it into our own list.

### 4. Developing the SPRDE/SE Duties and Tasks

Using the summary materials we generated from the sources listed above (e.g., "Identified Systems Engineering Best Practices or Deficiencies," "Systems Engineering Topics," and IDA's content reviews)—all of which are included in the appendixes—IDA began to create a list of SPRDE/SE duties and tasks. We reviewed each of the summaries, pulling out the material that was most appropriate for today's systems engineering environment and rewriting the material as needed to be in the form of a "duty or task." The authors started with the bottom-up sources—the existing and past SPRDE/SE competencies, TLOs, and ELOs. After sifting through those resources, we next went through the LMI competencies, again selecting those appropriate to today's SPRDE/SE

workforce for the SPRDE/SE Duties and Tasks list. Best practices and deficiencies were next, followed by the systems engineering hooks and finishing with the table of topics to make sure that none of the important systems engineering topics was left out. In an effort to be consistent with the Systems Engineering chapter of the *Acquisition Guidebook*, we organized the Duties and Tasks list according to the sections in that chapter of the *Guidebook*. Some material, such as information on systems engineering by phases, was taken directly from the Systems Engineering chapter of the *Guidebook*. IDA also organized the materials by certification level, putting systems engineering theory into Level 1, systems engineering by acquisition phases into Level 2, and management and leadership information into Level 3. IDA's list of SPRDE/SE Duties and Tasks can be found in Appendix K.

## B. SPRDE/SE PERFORMANCE OBJECTIVES

IDA delivered the draft list of SPRDE/SE Duties and Tasks to the Enterprise Development office on 19 May and we met with DAU representatives—John Snoderly and George Prosnik—and representatives of the Enterprise Development office shortly thereafter. After reviewing the Duties and Tasks, John Snoderly, Program Director for SPRDE/SE Curriculum, and George Prosnik, Director, Engineering and Technology Center, DAU Curriculum Development Support Center (CDSC), recommended that we develop a shorter, more succinct product from the Duties and Tasks. They indicated that the Duties and Tasks in their current form might overwhelm the SPRDE FIPT.

At that same meeting, we collaboratively developed a shorter list of Duties and Tasks in the form of Performance Objectives. Taking one or two of the most encompassing Duties and Tasks from each subject area, we rewrote them as POs. The POs, from 27 May 2004 are attached in Appendix L. The DAU representatives took the Duties and Tasks indicating that the detail would be useful for them in developing TLOs, ELOs, and course material for the certification courses. They also told us that they would do a gap analysis to determine the extent to which the POs we developed that day were covered by the existing course material in SYS 201A and B and SYS 301.

## C. SPRDE/SE LEARNING OUTCOMES

When the FIPT members saw the POs and were concerned that they might lack important detail, they decided to expand the POs to include more specific activities by certification level. The new list became "Learning Outcomes." At that 1 July FIPT meeting, the group assigned specific individuals to expand the POs. IDA was assigned to expand the systems engineering processes, while others were assigned other sections of

the POs. IDA reconsidered the Duties and Tasks we developed previously in the area of systems engineering processes, and submitted that list divided into the three certification levels. A current list of the LOs, dated 31 August 2004 can be found in Appendix M. This is the version that the SPRDE/SE FIPT delivered to DAU.

# VI. NEXT STEPS AND RECOMMENDATIONS

## A. NEXT STEPS

At this time, the SPRDE/SE FIPT has provided Duties and Tasks, Performance Objectives (POs), and, most recently, Learning Outcomes (LOs) to DAU as guidance for the certification courses. DAU is in the midst of conducting a gap analysis to determine which of the LOs are covered by existing SPRDE/SE course material. In the period to follow, DAU will be developing TLOs, ELOs, and course material to support the LOs. Meanwhile, in addition to reviewing DAU's SPRDE/SE TLOs, ELOs, and course material, the SPRDE FIPT will begin reviewing the systems engineering-related material in the other career fields/paths.

### 1. Reviewing Systems Engineering Material for Other Career Fields/Paths

Systems engineering material is primarily covered in DAU's SPRDE/SE certification courses, but it is important for other career fields/paths as well. Everyone in the FIPT agreed that reviewing the systems engineering-related material in the SPRDE/SE path was the first step, and that now having a list of SPRDE/SE duties and tasks, POs and LOs would permit a gap analysis or mapping to determine whether other non-SPRDE/SE courses should cover some of the LOs. Mr. Schaeffer requested that SPRDE/SE FIPT review the systems engineering-related material in the courses outside the SPRDE/SE career path according to his priorities. He grouped the courses outside the SPRDE/SE career path into two "tiers." First tier courses were considered higher priority because they would likely have a greater impact on systems engineering than other courses. Acquisition (ACQ) and Program Management (PMT) courses are considered "first tier," while review of other courses such as those in the Production, Quality, and Manufacturing (PQM) career field were considered lower priority and were labeled "second tier." The list of "tiers" can be found in Appendix N.

IDA suggested that in order to modify course material from another career field/path, we first needed to understand how the courses are structured. Unlike the SPRDE/SE courses, not all of the PM courses are based on published TLOs or ELOs. For example, some of the courses intended for high-level acquisition personnel, are taught based on the demands and questions of the students. To help the Systems Engineering office better understand the courses they are trying to affect, IDA prepared a table

summarizing the PM and ACQ courses along with recommendations about how they should be addressed. It is attached in Appendix O.

The Enterprise Development Office recently asked IDA to begin the review of systems engineering-related materials in other career fields/paths by determining what SPRDE/SE material belongs in the ACQ 101 and 201 TLOs. We recently completed a comparison between the systems engineering policy and "hooks" to the ACQ 101 and ACQ 201 TLOs and ELOs and proposed revisions to the ACQ TLOs. The Enterprise Development Office will send the proposed TLO revisions to the Program Management FIPT for consideration.

### 2. DAU Course Development

DAU is currently conducting a gap analysis by comparing the SPRDE/SE LOs to the existing SPRDE/SE certification course material. After finishing the gap analysis, DAU will start developing TLOs and ELOs based on the LOs. IDA stressed that the FIPT has provided a large amount of material for three courses and suggested that we keep track of material currently in the DAU SPRDE/SE courses that might be lost.

## B. RECOMMENDATIONS

After participating in the ongoing review of SPRDE/SE education and training, we have some recommendations for the SE Office and the SPRDE/SE FIPT as they move forward with the remainder of the review or in their future reviews of the DAU material.

*Recommendation 1:* Conduct a more thorough requirements analysis of SPRDE/SE acquisition personnel and their needs for SPRDE/SE training. In the course of review, we did not have the time to do as much of the requirements development process, one of the most important processes in systems engineering, as we would have liked. Having a better sense of the requirements would have led to more complete criteria for reviewing the courses. It would be interesting, for example, to examine the areas where systems engineers have the most trouble in programs, and to emphasize those areas in the SPRDE/SE education and training. We attempted to do this through previous studies but did not have the real-time data that we needed. An analysis like this might also be useful in determining whether the certification courses are the resources that need update and investment or if courses that are more widely available on-demand (such as CLMs) might be a better approach. The assessment data needs to feed into the FIPT process.

*Recommendation 2:* DAU should clarify and standardize instructional terminology. If, rather than mandating use of a specific process, DAU wants to ensure

that each of the FIPTs can be flexible in their management of the career fields/paths, it would be helpful if DAU defined its terminology generically enough to allow for this variation. While the instructional terminology definitions in Chapter II are helpful as a starting point in understanding the education and training review process, the use of the terminology is confusing. Although the FIPT charter indicates that “Competencies” should be developed/reviewed, career fields/paths develop LOs, duties and tasks, and the like instead of competencies, hence our recommendation.

*Recommendation 3:* Define requirements carefully up front, and rigorously follow systems engineering processes. Our process, like so many programs’ processes, suffered from requirements changes along the way. For example, we started out with a goal to create duties and tasks, the requirement changed to develop POs, and the group finally settled on LOs. One example where we could have used stronger systems engineering processes was in configuration management—specifically tracking decisions made throughout the review process. Agendas and follow-up minutes are always developed for the SPRDE/SE FIPT, but perhaps this practice would be useful for the smaller meetings as well. Our experience indicated that decisions made at one meeting that necessitated follow-up actions were sometimes negated in future meetings. Another example relates to the configuration control of the review documents. The education and training review was a collaborative effort with participation from many people and organizations. Given the number of people and organizations editing documents, we may need to use more sophisticated ways of tracking documents’ versions and configuration. Perhaps we could make better use of the SE CoP workspace provided to the group by DAU for this purpose.

# Appendix A
# Wynne Memorandum: Policy for Systems Engineering in DoD

## WYNNE MEMO

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

FEB 20 2004

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Policy for Systems Engineering in DoD

Application of rigorous systems engineering discipline is paramount to the Department's ability to meet the challenge of developing and maintaining needed warfighting capability. This is especially true as we strive to integrate increasingly complex systems in a family-of-systems, system-of-systems, net-centric warfare context. Systems engineering provides the integrating technical processes to define and balance system performance, cost, schedule, and risk. It must be embedded in program planning and performed across the entire acquisition life cycle.

Toward that end, I am establishing the following policy, effective immediately and to be included in the next revision of the DoD 5000 series acquisition documents:

Systems Engineering (SE). All programs responding to a capabilities or requirements document, regardless of acquisition category, shall apply a robust SE approach that balances total system performance and total ownership costs within the family-of-systems, systems-of-systems context. Programs shall develop a Systems Engineering Plan (SEP) for Milestone Decision Authority (MDA) approval in conjunction with each Milestone review, and integrated with the Acquisition Strategy. This plan shall describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It shall also detail the timing, conduct, and success criteria of technical reviews.

In support of the above policy, the Director, Defense Systems shall:

a. Identify the requirement for a SEP in DODI 5000.2, and provide specific content guidance tailorable by the MDA in the Defense Acquisition Guidebook.

b. Assess the adequacy of current Department-level SE related policies, processes, practices, guidance, tools, and education and training and recommend to me necessary changes.

c. Establish a senior-level SE forum with participation from the Military Departments, and appropriate defense agencies, as a means to collaborate and leverage activities within the components and to provide a forum to institutionalize SE discipline across the Department. A goal of this forum will be extending the SE process to address family-of systems, system-of-systems capability-based acquisition.

d. For programs where I am the MDA, review each program's SEP as part of the preparation for Defense Acquisition Board Milestone Reviews (DAB) and other acquisition reviews, provide me with a recommendation on the program's readiness to proceed during the DAB. Together with other members of the OSD staff, lead program support assessments to identify and help resolve issues to ensure program success.

To assist in these efforts, each Component Acquisition Executive and defense agency with acquisition responsibilities will, within 90 days, provide the Director, Defense Systems its approach and recommendations on how we can ensure that application of sound systems engineering discipline is an integral part of overall program planning, management, and execution within both DoD and defense industry. Further, I direct each Component Acquisition Executive and those defense agencies with acquisition responsibilities to provide, within 30 days, a flag officer or Senior Executive Service-level representative to participate in the Director, Defense Systems-led systems engineering forum. The first such forum will be held within 60 days.

I need your assistance to ensure we drive good systems engineering processes and practices back into the way we do business. We can accomplish this goal by establishing clear policies, reinvigorating our training, developing effective tools, and using and institutionalizing best practices, applying performance incentives, and making systems engineering an important consideration during source selections and throughout contract execution. Collectively these actions will reinvigorate our acquisition community - including our industry partners - thus assuring affordable, supportable, and above all, capable solutions for the warfighter.

Michael W. Wynne
Acting

# Appendix B
# Lamartin Memorandum: Implementing Systems Engineering Plans (SEP) in DoD

## LAMARTIN SEP MEMO

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

March 30, 2004

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Implementing Systems Engineering Plans in DoD – Interim Guidance

On February 20, 2004, the Acting Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) took a major step to reinvigorate DoD Systems Engineering by signing into policy a requirement that "All programs responding to a capabilities or requirements document . . . shall develop a Systems Engineering Plan (SEP) for Milestone Decision Authority (MDA) approval in conjunction with each Milestone review." This memorandum provides interim guidance concerning the purpose and content of these plans. I look forward to working with your representative to the new Systems Engineering Forum to capture best practices and mature this guidance over time. The SEP will be addressed more completely in future updates to the Defense Acquisition Guidebook.

The purpose of the SEP is to lay out a plan that should guide all technical aspects of an acquisition program. Program managers should establish the SEP early in the program definition phase and update it at each subsequent milestone. It is intended to be a living document, tailored to the program, and a roadmap that supports program management by defining comprehensive systems engineering activities, addressing both government and contractor technical activities and responsibilities. The SEP describes the program's overall technical approach, including systems engineering processes; resources; and key technical tasks, activities, and events along with their metrics and success criteria. Integration or linkage with other program management control efforts such as integrated master plans, integrated master schedules, technical performance measures, and earned value management is fundamental to successful application.

There is no prescribed format for the SEP. However, it should address how systems engineering will support the translation of system capability needs into an effective, suitable product that is sustainable at an affordable cost. Specifically, a well-prepared SEP will address the integration of the technical aspects of the program with the overall program planning, systems engineering activities, and execution tracking to include:

- The systems engineering processes to be applied in the program (e.g., from a standard, a capability maturity model, or the contractor's process). Describe how the processes will be implemented and how they will be tailored to meet individual acquisition phase objectives. Describe how the SE processes will support the technical and programmatic products required of each phase.

- The system's technical baseline approach. Describe how the technical baseline will be developed, managed, and used to control system requirements, design, integration, verification, and validation. Include a discussion of metrics (e.g., technical performance measures) for the technical effort and how these metrics will be used to measure progress.

- Event-driven timing, conduct, success criteria, and expected products of technical reviews; and how technical reviews will be used to assess technical maturity, assess technical risk, and support program decisions. SEP updates shall include results of completed technical reviews.

- The integration of systems engineering into the program's integrated product teams (IPTs). Describe how systems engineering activities will be integrated within and coordinated across IPTs; how the IPTs will be organized; what SE tools they will employ; and their resources, staffing, management metrics, and integration mechanisms. Describe how systems engineering activities are integrated in the program's overall integrated schedules.

For programs where the USD(AT&L) is the Milestone Decision Authority (MDA), components shall submit the SEP to me at least 30 days before the scheduled Defense Acquisition Board (DAB) milestone review. My staff and I will evaluate each program's SEP in preparation for the DAB review and in support of Defense Systems' other acquisition and assessment support activities. I encourage all MDAs to take similar actions.

The referenced SEP policy is already in effect, so I urge you to distribute this guidance memorandum to your Program Executive Officers, Program Managers, and/or Systems Commanders. For additional clarification or guidance on SEP tailoring, please contact Mr. Mark Schaeffer, Director, Systems Engineering, (703) 695-7417, mark.schaeffer@osd.mil, or Mr. Bob Skalamera, Deputy Director, Systems Engineering (Enterprise Development), (703) 695-2300, robert.skalamera@osd.mil.

Glenn F. Lamartin
Director, Defense Systems

# Appendix C
# CONTENT REVIEW OF SYS 201

## CONTENT REVIEW OF SYS 201A

# General

- Update to reflect new 5000 and 3170 environment
- Replace the current model with the Vee model or at least perform a closer review of the course material to ensure that the characteristics of the Vee model are being addressed
  - Much of the lesson content on the *processes* associated with the old model is still relevant—Requirements Analysis, Functional Analysis and Allocation, and Synthesis (Physical Solution)
- Need a good scrub of the content to be sure that the sections really add value in terms of having someone walk away with a better sense of SE—matching competencies to lessons
- In accordance with IDA's planned approach to developing competencies, focus first on the minimum set of things that one should know about SE. From reviewing the courses, it seems that requirements must have been promulgated that focused on the specifics of a particular interest area and that a coherent, bigger-picture view of the systems engineering process became dominated by these more restricted topics.
- Decide how to refer to the idea of a Systems Engineering Plan when the SEP acronym is already associated with the systems engineering process within the community
  - Consider the development of a new lesson that covers a Systems Engineering Plan
- Resequence the lessons logically.
- As per SPRDE/SE FIPT February 2004 decision, revise this course to focus on the Vees and the phases of the acquisition life cycle.

| Lesson Number | Lesson Name | Review Comments |
|---|---|---|
| 1 | Systems Acquisition Overview | • This lesson, particularly the portion focused on Acquisition Reform, needs to be revised given the release of the new 5000 and 3170 documents. In general, DAU doesn’t date their references, which could cause confusion. And now Acquisition reform is being reformed. |
| 2 | Integrated Product and Process Development | • Need to stress integration of IPTs and make sure there is no SE IPT. |
| 3 | Systems Engineering | • This lesson is obviously based on the old SE model. Since the focus now is a Vee-model approach, changes need to be made to this section. |
| 4 | Technology Development and Insertion | • One of the most easy to follow lessons with a lot of good information. Needs to be updated to talk about Pre-Milestone B SE activities and technology development and insertion in the new spiral development and evolutionary acquisition environment. |
| 5 | Environmental, Safety, and Health | • Blurring of the lines between the content of a course to teach about SE and a more general course about acquisition and the various requirements and regulations that pertain to it. This may be a result of the past competency analyses and negotiations among courses and FIPTs.<br>• Should have a lesson on the “ilities” in general and how SE integrates their considerations into the design of both the product and processes. Then ESOH is one of those ilities.<br>• Snoderly briefed in Dec 03 that Exercise 5 was revised to provide clearer instruction to students. |
| 6 | Systems Engineering Planning | • This lesson touches on the SEMP, so will want to make sure that it is addressing the types of things that are being envisioned for the Systems Engineering Plan. It will warrant some additional material than that which is currently contained in this lesson. |
| 7 | Requirements Analysis | • References the MNS and ORD as inputs to Requirements Analysis, so needs to be updated to reflect the ICD, and possibly the CDD |
| 8 | Functional Analysis and Allocation | • This lesson highlights the Functional Architecture, referring to it as the primary output of Functional Analysis. |
| 9 | Synthesis | • This lesson does not really explain enough about any one topic and topics covered aren’t necessarily the right things to cover. An approach like Bob’s that highlights reviews as they are tied to the acquisition system and any other checklist-type approach is the better way to go. How do we ensure that taking this course, especially in an online format, is actually |

| Lesson Number | Lesson Name | Review Comments |
|---|---|---|
| | | providing what is needed? Do people just sort of read through this material, but don't necessarily understand why it is important or how one would use it. Need to see the test questions.<br>• Recursive Nature Technical Data Package (TDP) topic area text doesn't seem to explain TDPs, but instead talks about the Verification Loop<br>• Open Systems Analysis topic area text really doesn't match the section heading<br>• Simulation-Based Acquisition (SBA) topic area probably shouldn't refer to this in caps or use the acronym—not an initiative any more<br>• Joint Programs (Joint Modeling and Simulation system (JMASS), Joint Simulation Systems (JSIMS), and Joint Warfare Simulation (JWARS) [Not sure that all of these are still active programs. Either JSIMS or JWARS may have gone away?] |
| 10 | Verification | • The Systems Engineering Process is referred to in this course as SEP. This will cause confusion if the office decides to make the SEMP the Systems Engineering Plan, another SEP.<br>• "Open Systems Testing"--this section focuses on "conformance testing" rather than open systems testing as the section heading suggests.<br>• There is a blurring of the lines between verification and validation. This distinction needs to be made clear and should follow from getting away from the old 499B model, which didn't include Validation. Bob's Vee models should at some level. |
| 11 | Systems Engineering Process Outputs | • In "Development of the Specification Tree in Relation to the Life Cycle Phases," the text doesn't really highlight the Life Cycle phases portion of this section's title--is more focused on the specification tree. |
| 12 | Work Breakdown Structure | • A pretty thorough introduction to WBS. |
| 13 | Solicitations and Source Selection | • This is one of those lessons that does not have the most direct SE relevance. Follow up with mappings to competencies and reviews of the ACQ courses. |
| 14 | Trade Studies | • With Bob wanting to emphasize the need for trades between the various portions of the Vee-model, need to take a closer look at this lesson on Trades to make sure that it captures what is necessary. |

| Lesson Number | Lesson Name | Review Comments |
|---|---|---|
| 15 | Cost Containment | • This lesson focuses predominately on CAIV. |
| 16 | Configuration Management | • This lesson contains information on baselines.<br>• Interface Control Document (ICD) is discussed—now that acronym stands for Initial Capabilities Document as well. |
| 17 | Risk Management | • This lesson still references the old 5000, so will need to be revised to reflect the new 5000. Also, in this lesson, like some of the others, the flow of the material is strange. For example, the Risk Management Process Steps section has four steps interspersed with a number of other items, which should really probably be handled as subs to those steps.<br>• Sections on “Risk Management Policy and Procedures” (as per the contractor’s corporate policy) and “Corporate Policy and Procedures Documents”--distinction between them is not clear.<br>• Sections on Risk Management appear in other lessons (CAIV, Planning, PBBE), but there is no clear reason why the duplication exists or what the linkages are between the lessons. |
| 18 | Technical Performance Measurement | • The material in this section is organized strangely. Reorganization would make it flow more logically. And why is one whole lesson devoted to this topic? Ranking in importance from competencies?<br>• For example, sections labeled “Technical Performance Measurement (TPM)” and “Concept of TPMs” appear later in the lesson than other topics. |
| 19 | Technical Reviews | • This lesson mentions that technical reviews are performed after each level of development. Bob’s Vee model, however, has some reviews happening at different points in the Vee. This is an inconsistency that will have to be dealt with. Need to make sure the list of typical technical reviews covered match up with those being proposed by Bob. Also still has the reviews linked to the previous acquisition phases.<br>• John Snoderly briefed in Dec 03 that they revised Exercise 19 for the on-line portion, but also briefed that this exercise would be deleted from the on-line portion (201A) and incorporated into the capstone exercise in 201B, which will emphasize technical reviews. |
| 20 | Product Improvement | • Material in this lesson doesn’t really warrant its own separate lesson. It could be just as easily folded into another lesson that talks about how SE can be used for the development of new systems and the improvement of already in development and existing systems. |

**CONTENT REVIEW OF SYS 201B**

The material in the Review Resources portion of SYS 201B that we have appears to be the same as the SYS 201A course material reviewed above. John Snoderly from DAU briefed in Dec 03 that a capstone exercise was being developed for implemention in Jan 04 to—

- Tie together many of the SYS 201B topics discussed during the week as a final exercise
- Incorporate and emphasize Technical Reviews, thus eliminating Exercise 19 from the on-line version

In his briefing at the first SPRDE/SE FIPT meeting, John Snoderly discusssed the following anticipated changes:

- Including a threaded exercise
- Becoming a “tools-based” course that incorporates software tools that students can use in exercises and take away with them on CD
- Enhancing lesson VGs: More dynamic and built upon SYS 201A materials

We never saw any VGs or any pictures at all for SYS 201A, only the on-line text.

# Appendix D
# REVIEW OF SYS 301

## CONTENT REVIEW OF SYS 301

- Recurring theme in SYS 301: Software practices often cover at least the concepts in Bob's hooks. Need to investigate why there is so much separation of the software material from just general systems material. Probably this stems from the days when the SIS office existed.
- Lessons need a more logical flow
- As per SPRDE/SE FIPT February decision, Level 3 courses should focus on gaining the knowledge to lead or manage systems engineering. This course will need to be updated accordingly.

| Lesson Number | Lesson Name | Review Comments |
|---|---|---|
| 1 | Acquisition Policy and the Resource Allocation Process | • This first lesson has a slide dedicated to the new 3170.01c and JCIDS process. Without being in the classes, it is difficult to know how much of the process is covered. But, it may be helpful to include more about JCIDS and what the functional capabilities boards do and how it all relates to the integrated architectures PMs are being asked to develop?<br>• Snoderly briefed in Dec. 03 that this is being updated to reflect Policy/PBBE changes. |
| 2 | Architecture and Interoperability (from TOC)/ Interoperability and Architecture (from Lesson Assignment Sheet) | • GIG is mentioned on a slide, but maybe it should be further explained? Perhaps it is explained elsewhere (p. 106)<br>• One of the slides says that interoperability is "information exchange between two or more parties." This definition of interoperability does not seem to be broad enough for SE. Should interoperability include more than that? (p. 107)<br>• This lesson discusses the Interoperability KPP and Interface Exchange Requirements (IERs). These may have been modified or renamed recently, and if so, they would need to be modified within this lesson as well.<br>• Snoderly briefed in Dec. 03 that this is being updated to better prepare students for new case study in Lesson 8 (?). |
| 3 | System Analysis and Control Tools | • Configuration management is included as a general topic, not specific to requirements, for example<br>• 499B-like model is used to illustrate the detailed systems engineering process in the student reference section |

| Lesson Number | Lesson Name | Review Comments |
|---|---|---|
| | | • There is a systems engineering Vee used on p. 150 relating to the Acquisition process. One Vee is used across systems integration (SI) and system demonstration (labeled SDD in the diagram). Vees will now be focus of the 201 courses.<br>• Mention of technical reviews here (p. 166)<br>• Case Study<br>• Snoderly briefed in Dec. 03 that this is not being changed. |
| 4 | Integrated Product and Process Development | • What about the government vs. contractor roles in the Gov't-LTI organizational structure used by programs like FCS, where there are government and contractor co-leads for each of the IPTs. Some clarification on the division of labor, etc. would be helpful. Issue of where the responsibility and funding lie.<br>• Systems Engineering Integration of Program IPTs should be highlighted and scrubbed to be sure there are no SE IPTs.<br>• Mars Rover Exercise<br>• Snoderly briefed in Dec. 03 that this is not being changed. |
| 5 | Technology Management | • This lesson could be appropriate beyond just SPRDE because it explains the process and policies, but does not seem to be specific to SE.<br>• Snoderly briefed in Dec. 03 that Huntsville is incorporating new case focusing on Technology Transition. |
| 6-01 | DoD Software Acquisition Planning and Strategy (from TOC)/ The DoD Software Acquisition Management Environment (from Lesson Assignment Sheet) | • Should be scrubbed to see what is software-specific or broadened to talk about system Acquisition and Strategy …<br>• CMM is mentioned in a teaching note with respect to process maturity. Why isn't CMMI mentioned instead? It is mentioned in a later lesson. |
| 6-02 | DoD Software Acquisition Control and Methodology (from TOC)/ SW Engineering Process (from Lesson Assignment Sheet) | • Discussing the different software development paradigms is included as one of the ELOs. It would be nice if the lesson could get more into the advantages and disadvantages of the different development paradigms—which ones are most appropriate when (there is a little bit of this in the next lesson).<br>• 499B-like model used to describe the systems engineering process |

| Lesson Number | Lesson Name | Review Comments |
|---|---|---|
| 6-03 | DoD Software Acquisition Planning and Strategy (from TOC)/ SW Best Practices (from Lesson Assignment Sheet) | • The need for a "Requirements Management Plan" is mentioned in the Implementation Guidelines under one of the recommended best practices in this lesson: *Manage and Trace Requirements* (p. 370)<br>• The Defense Science Board Task Force Study on Software (Nov 2000) also mentions requirements management: "technical and management practices for better requirements management were described and recommended long ago… these practices are the hallmark of commercial best practice but they remain largely underutilized in the acquisition and development of defense software." (p. 415)<br>• Some of the best practices listed in this chapter apply beyond software (e.g., independent, expert reviews suggested in the DSB study) |
| 6-04 | Software Management Exercise (Case Scenario and Workshop) | • Case Study<br>• Snoderly briefed in Dec. 03 that there is now only one Software Management lesson, not the 4 shown in the course material reviewed here. Its focus is metrics and best practices and the case study is the same. |
| 7 | Concept and Technology Development | • Should this lesson exactly match the acquisition phases? This lesson relates to both 1) Concept Refinement and 2) Technology Development<br>• Case Study |
| 8 | Environmental, Safety, and Occupational Health. | • Case Study<br>• Snoderly briefed in Dec. 03 that this lesson is being combined with International lesson below and being folded into new lesson titled "Transition to Systems Acquisition." |
| 9 | Benefits and Challenges of International Cooperation | • No lesson comments<br>• See above |
| 10 | System Definition | • 499B-like model used as the SE Process Model in slides<br>• Should this lesson map exactly to an acquisition phase? It relates to System Development and Demonstration<br>• Case Study<br>• Snoderly briefed in Dec. 03 that System *Defense* Case Study was shortened up a bit. Was that this? |

| Lesson Number | Lesson Name | Review Comments |
|---|---|---|
| 11 | Design, Fabrication, and Test | • Should this lesson map exactly to an acquisition phase? Like the previous lesson, it relates to System Development and Demonstration.<br>• Snoderly briefed in Dec. 03 that this lesson received minor updates.<br>• Exercise/ Case Study |
| 12 | Current Events and Issues | • The idea of dedicating a lesson to sharing individual experience is a good one. The students' experience and examples should provide additional case study-like discussions.<br>• Snoderly briefed in Dec. 03 that this lesson was unchanged. |
| 13 | Production: IPPD and the Paladin Enterprise | • Browsing through the case study, the 499B model is shown a number of times. This should be replaced with the Vee.<br>• Should this lesson map exactly to an acquisition phase? It relates to a combination of two phases: Production and Deployment and Operations and Support.<br>• Case Study<br>• Snoderly briefed in Dec. 03 that this lesson was unchanged. |
| 14 | Deployment, Operations, and Support | • Case Study<br>• Should this lesson map exactly to an acquisition phase? It relates to a combination of two phases: Production and Deployment and Operations and Support.<br>• Snoderly briefed in Dec. 03 that DOS was cancelled. Is there any concern about this information having been lost? |
| 15 | Improvements to Existing Weapon Systems | • The title of this lesson, the TLO and one of the ELOs is specific to weapon systems. Does that make sense? Shouldn't the lesson be broader? There are more kinds of systems than just weapon systems. Maybe rename to something about Evolutionary acquisition and spiral development?<br>• The differences between evolutionary acquisition and spiral and incremental development don't seem to be well understood in the community, so maybe this lesson is a way to clarify that point. Could there be examples of both spiral and incremental approaches to show how the two are different and where each is appropriate? Maybe a case study that asks the student to pick a development approach (which could include the two of these)?<br>• Snoderly briefed in Dec. 03 that Product Improvement was cancelled. |

| Lesson Number | Lesson Name | Review Comments |
|---|---|---|
| 16 | Modeling and Simulation | • Page 194 includes some other organizations' versions of SBA (e.g., SMART, SEBA). The course may already cover this, but it would be helpful to understand the differences between these different flavors of SBA, if they still exist.<br>• Snoderly briefed in Dec. 03 that this lesson was shortened up a bit to reflect true content. |
| 17 | Professional Ethics Case | • Case Study |
| | Spectrum Management | • Snoderly briefed in Dec. 03 that this is a new one-hour lesson whose content is being worked by DoD Spectrum Management people. |
| | Evolutionary Acquisition Capstone Case | • Snoderly briefed in Dec. 03 that this capstone lesson will have 6 case studies dealing with different aspects of EA/product improvements/OPS support/etc. |

# Appendix E
# REVIEW BY HOOK

## REVIEW BY HOOK

| Hook | SYS 201 | SYS 301 |
|---|---|---|
| Systems Engineering Strategy | This hook is not explicitly called out in any of the SYS201 A & B lesson materials. [Unless this is really something that could possibly be covered under Lesson 6: Systems Engineering Planning in SYS 201 A?]<br>In most instances, "strategy" is used to refer to either an Acquisition or S&T strategy. In Lesson 6: Systems Engineering Planning, however, there were several quotes related to what a contractor's SEMP should include that may start to get at what the office is looking for with this hook:<br>• "A technical strategy description that ties the engineering level effort to the higher-level management planning."<br>• "A description of how the SEP will be tailored and structured to complete the objectives stated in this strategy."<br>• "A resource plan that identifies the estimated funding and schedule necessary to achieve the strategy." | • No mention of a Systems Engineering Strategy exactly, but there are a couple of lessons in SYS 301 with "software acquisition planning and strategy" in the title (specifically, the TOC title, not the actual lesson title). |
| Upfront and early addressing of SE (all acquisition phases, not just SDD) | Refers to the application of SE throughout in terms of a program, which probably is meant to entail an acquisition program. If this is the case, then SYS 201A & B do not explicitly address the use of SE pre-Milestone B. Perhaps the closest that it gets to addressing the pre-Milestone B part is through Lesson 4: Technology Development and Insertion in SYS201 A, which acknowledges technology development programs and the insertion of technologies.<br>***In a search for "early" in SYS 201 B: Review Resources:*** This is a confusing one, because for the | • Some of the lessons within this course are divided roughly by acquisition phase. For example, Lesson 5: Technology Management, Lesson 7: Concept and Technology Development, Lesson 10: System Definition, Lesson 11: Design Fabrication and Test, Lesson 13: Production, Lesson 14: Deployment, Operations and Support. Perhaps the lessons should be divided up specifically according to the 5000 phases? The downside of this, of course, is that if the phases change, as they could do, a rewrite of the lesson would be needed. |

| Hook | SYS 201 | SYS 301 |
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| | most part when they refer to early in a program, it means after Milestone B. Other times, however, you get the impression that early means prior to this, but not sure who has purview at that time since the program hasn’t been initiated yet. The following are some instances where pre-Milestone B does come up:<br>• Lesson 5: Environmental Safety and Health Considerations: “The best time to integrate ESOH considerations into the SEP is early in the life cycle, during Concept Exploration, Technology Development, and System Integration work activities. It is easier and less costly to make changes to hardware. For most programs, the PM prepares a PESHE by milestone B.”<br>• In Lesson 6: Systems Engineering Planning, a pre-Milestone B activity is mentioned related to T&E<br>• Lesson 9: Synthesis: “Several alternative hardware and software configurations must be developed to satisfy the requirements of the Functional Architecture. Early on in the life cycle (before Milestone A and the concept exploration work effort), these alternatives actually represent systems and are used to develop preliminary concepts for the system’s design.”<br>• Lesson 12: Work Breakdown Structure: “Though the Concept Refinement and Technical Development phases, WBSs are usually in an early stage of development. It is not until the system integration work effort in the System Development and Demonstration phase that the system is described by the System Specification and the WBS expands to include lower levels. By the end of the Production and Deployment phase the WBS is fully defined to its lowest elements.” | • The lessons that are roughly divided by specific acquisition phases (e.g., Concept and Technology Development; System Definition; and Design, Fabrication and Test; Production: IPPD and the Paladin Enterprise; and Deployment, Operation and Support) have TLOs that include how systems engineering is used within that phase.<br>• Lesson 5: Technology Management is more about the DoD S&T process in general than specifically what systems engineers need to be doing in the S&T phase. Needs to focus more on SPRDE SE role.<br>• The TLO for Lesson 7: Concept and Technology Development is “to evaluate the effective execution of the entire Concept and Technology Development phase using a systems engineering approach.” So the idea of performing SE from the start of the program is included here. There is also a slide (p. 608) titled “Systems Engineering in Concept Exploration.” “Acquisition Strategy Elements” are also included here, such as Open System Objectives; Cost, Schedule, and Performance Risk Management, CAIV, etc. |

| Hook | SYS 201 | SYS 301 |
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| | • While discussing CAIV in Lesson 15: Cost Containment, it is mentioned that “aggressive yet realistic cost objectives” should be established in the program and that warfighter’s should be involved, early and continuously, in establishing and modifying goals throughout a program. Also in discussing TOC, it seems to indicate pre-Milestone B work when it states: “TOC objectives should be addressed early in the design process. This allows performance objectives to be developed that are achievable and affordable based on actual development and additional analysis during System Development and Demonstration (SD&D).” Further, “Additional cost/performance/schedule trades as well as specific cost reduction studies and actions may be necessary early in the acquisition process to achieve TOC reductions. This may require additional up-front funding.”<br>• Lesson 17: Risk Management talks about the need for “initial system-level risk assessments” during the Concept and Development phase | |
| Lead systems engineer assigned at program inception | This hook is not explicitly called out in any of the SYS201 A & B lesson materials<br>***In a search for “systems engineer” in SYS 201 B: Review Resources:*** The term lead systems engineer does not appear. A systems engineer comes up periodically throughout the text. In Lesson 13: Solicitations/Source Selections it states that the systems engineer is “to support the development and maintenance of the business contract.” If the systems engineer is supposed to assist in the development of a business contract, it would seem that that individual would have to be on board since program inception (Milestone B), if not before. | • Haven't seen specific reference about the appointment of a lead systems engineer. But in doing a terms search through the lessons, there are references to the lead of the systems engineering IPT. Some of the case studies place the student in the role of SE-IPT lead. These need to be taken out and emphasis placed on SE integration of IPTs. |

| Hook | SYS 201 | SYS 301 |
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| Acquisition components must maintain a robust systems engineering organization | This hook is not explicitly called out in any of the SYS201 A & B lesson materials | • No specific references to maintaining robust systems engineering organization. |
| Lead Engineer is jointly accountable to PM and functional leadership | This hook does not appear to have been explicitly called out in any of the SYS201 A & B lesson materials. | • No specific references to the lead engineer jointly accountable to PM and functional leadership. These kinds of issues are addressed in the IPPD Handbook and should be put in the Guide as well. |
| SE spans IPT (not located in an "SE IPT") | <u>Lesson 2</u> of SYS201 A & B is Integrated Product and Process Development and includes topics such as IPPD Concepts, IPPD Relationships and IPT Concepts. There is also a section under IPPD Concepts titled "Relationship of Systems Engineering to IPPD," which includes the following statements: "IPPD is a management technique that integrates systems acquisition functions;" and "Systems engineering, on the other hand, is the structured/disciplined approach that addresses the technical aspects of a program within an IPPD framework." Given the way that IPTs have been misused at times, however, perhaps it would be worth explicitly saying something to the effect of this hook somewhere in this lesson. | • References refer to the SE IPT, as opposed to SE spanning the IPTs. See the comment about the "Lead systems engineering assigned at program inception." |
| Systems Engineering Plan (SEP) established early in the program definition and updated continuously as the program matures, through system operations and support | <u>Lesson 6</u>: Systems Engineering Planning in SYS201A addresses the following major topics: Program vs. Technical Planning, Control Criteria and Metrics, Event Criteria vs. Time-based Accomplishment Planning, Influence on System Design, and Contractor efforts. It talks at least a little about the SEMP under the section on Technical Plans and also provides a little more information on why one would want systems engineering plans. No real information about the timing of the development of a SEP or a schedule for its continuous update throughout the course of the | • SEMP (Systems Engineering Management Plan) is mentioned in Lesson 6-03: SW Best Practices (p. 370–371) as a place where requirements traceability to address system, hardware, and software and process should be defined. Early and continuously updated not specified.<br>• Note that the acronym SEP is used to mean "Systems Engineering Process" in Lesson 3: System Analysis and Control Tools on p. 149, as well as on p. 186 and p. 202 (Lesson 14: Deployment, Operations and Support). There are several |

| Hook | SYS 201 | SYS 301 |
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| | program | mentions of various plans (risk management, software development, etc).<br>• Individual plans (test plans, project plans, management plans, etc.) are discussed throughout the lessons. |
| SEP description of systems integration on the program IPTs, including resources, staffing, management metrics, and integration mechanisms | In addition to the information described in the hook above, Lesson 6's section on Control Criteria and Metrics includes information on metrics in management and product metrics, as well as MOEs and MOPs. Little if any specific information however that describes the SEP and a description of systems integration on program IPTs to include resources, staffing and integration mechanisms. | • Chapter 6-01: The DoD Software Acquisition Management Environment includes a passage about how systems integration (specifically software to software, software to hardware, and software to systems) needs to be included in the master timeline, but have not seen specific reference that it needs to go into a SEP.<br>• There is an entire lesson on "System Analysis and Control Tools" (Lesson 3), but have not seen specific mention of the need to document management metrics in the SEP.<br>• As mentioned in the comments for the previous hook, there are individual plans mentioned throughout the lesson that may contain the topics in this "hook", but no specific mention of a SEP. |
| Independent Subject Matter Experts on SETRs (Systems Engineering Technical Review) | Lesson 19: Technical Reviews does not specifically mention the issue of those involved in technical reviews being independent. However, under "General Principles" in the Purpose of Technical Reviews section, it states that review participants are designated and "should include all stakeholders who are knowledgeable of the area concerning the technical review (includes subcontractors, vendors, and suppliers). | • Noticed that there is specific lesson on Technical Reviews in Sys 201. Information about technical reviews appears to be spread out in various lessons of 301—should it be combined into one lesson for 301, or is it adequately covered in 201?<br>• Lesson 6-01: The DoD Software Acquisition Environment. The words "USD(S&T) independent 'expert review'" are included in a slide referring to DoD SAM Key Policies from the Defense Acquisition Guidebook (p. 317).<br>• Lesson 6-03: SW Best Practices includes the Defense Science Board Task Force on Defense Software report (or at least excerpts of it). One of the |

| Hook | SYS 201 | SYS 301 |
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| | | best practices in this report is to "Initiate Independent Expert Reviews." The DSB recommended institutionalizing them for DoD ACAT I-III software intensive programs. The report recommends that the IER team be "a small group of professionals with the appropriate mix of experience… should be drawn from government, academia, and contractor resources… no IER team should be directly involved in the program." (p. 20-21) Sample topics and agenda are included.<br>• Lesson 13: IPPD & The Paladin Enterprise says that "The nature of technical reviews is confirmation; they validate and coordinate activities which preceded them. For example, no new information should be presented in a technical review. All pertinent information must have been reviewed and considered adequate by the government prior to review…" There are also brief discussions of Production Phase Evaluations and Technical Reviews/Audits/Tests such as PCA, PAT&E (Production, Acceptance, Test and Evaluation), FOT&E (Follow-up Operational Test and Evaluation). Do these technical reviews also need to have SMEs, independent reviewers, etc. even though they do not appear to be included in the 5000 timeline? |
| SETR chaired by an independent technical authority | This hook is not explicitly called out in any of the SYS201 A & B lesson materials | • See comment about "Initiate Independent Open Reviews" in Lesson 6-03 in previous hook.<br>• Lesson 07: Concept and Technology Development includes a case-based lesson and content about preparing for Technology Development Decision Reviews and Milestone B. One of the ELOs is "to evaluate the results of Concept and Technology Development Phase concept analyses by using |

| Hook | SYS 201 | SYS 301 |
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| | | technical reviews" but there does not appear to be any guidance about who conducts the reviews, if there are SMEs involved, or whether or not the technical reviews are required contractually.<br>• Lesson 10: System Definition includes "Holding Technical Reviews" as one the SE Activities within the Synthesis phase of the SE Process Model (would it be more appropriate to use the Vee here instead?). There are specific questions listed for System Requirements Reviews and System Functional Reviews (one slide for each review) but again, no mention of who does the review, etc. |
| SETRs addressed in and required by contractual documents | Again under "General Principles" in the Purpose of Technical Reviews section of Lesson 19: Technical Reviews mentions "the contractor having the contractual responsibility for conducting the reviews and having all the data, models and equipment at their site | • Lesson 03: System Analysis and Control Tools describes Technical Performance Measures, and how they should be tracked by the contractor and reported to the government contractually. There is also mention of the technical reviews in that TPMs should be reviewed during those reviews.<br>• Integrated Baseline Reviews are mentioned on a slide under the subtitle "Contract Approach" on p. 612 of Lesson 7: Concept and Technology Development. |
| Tailored technical reviews | The issue of tailoring is not specifically mentioned, but SYS201 A contains an entire lesson, Lesson 19: Technical Reviews, devoted to this topic. The major subject headers for this lesson include: Purpose of Technical Reviews, Types of Technical Reviews and Configuration Baselines and Technical Reviews. The specific reviews that are discussed are as follows: Alternative Concept Review (ACR), System Requirements Review (SRR), System Functional Review (SFR), Software Specification Review (SSR), Preliminary Design Review (PDR), Critical Design Review (CDR), Production Readiness Review (PRR), | • The "opportunity for tailoring" reviews is raised on a series of charts in lesson 6-02: SW Engineering Process (p. 348-350) describing the software engineering process. |

| Hook | SYS 201 | SYS 301 |
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| | Test Readiness Review (TRR), and System Verification Review (SVR).<br>“Tailored Technical Reviews” does not appear in SYS 201 B: Review Resource | |
| Technical baselines approved at reviews | The relationship between baselines and the reviews is established in the Configuration Baselines and Technical Reviews section of SYS201 A’s Lesson 19: Technical Reviews. In particular several of these relationships are highlighted: System Functional Review and the functional baseline, between Preliminary Design Review and Critical Design Review and the allocated baseline, and a “Physical Configuration Audit performed on first system manufactured on FRP based on a detail specification vs., the actual system, resulting in a product baseline.” “Technical baselines” does not appear in SYS 201 B: Review Resources | • “Technical reviews” are only mentioned twice in the 301 course<br>• There is mention of technical reviews as “quality gates” (Lesson 6-01: The DoD Software Acquisition Management Environment) on p. 308: “PMs should approach the formal review as a checkpoint for determining whether or not the project is ready to proceed to the next phase.”<br>• The same slides that describe the “opportunities for tailoring” reviews also discuss baselines as well. For example, ASR, SRR, SDR and SFR are associated with the Functional Baseline; SSR and PDR are associated with the Allocated Baseline; and CDR, TRR, SVR and PCA are associated with the Product Baselines (p. 348-350). As with so many of the other hooks, this should also be covered in more general lessons that are not focused only on software. |
| Technical reviews are event driven vice schedule driven | There is a specific statement to this effect under “General Principles” in the Purpose of Technical Reviews section of SYS201 A’s Lesson 19: Technical Review | • There is mention of event-based technical reviews on p. 166 of Lesson 3: System Analysis and Control Tools |
| Systems Engineering in Total Life Cycle Systems Management | Neither “total life cycle system management” nor “total life cycle” appears in SYS 201B Student Guide. However, in SYS 201B Review Resources under Lesson 3: Systems Engineering, the “Total Systems Approach” states: “The PM shall be the single point of accountability for accomplishing program objectives for total life-cycle systems management, including sustainment. The PM shall apply human systems | • Is this similar to Systems Engineering in all phases of a program—not just SDD? There are lessons devoted to the specific acquisition phases (e.g., Concept and Technology Development; System Definition; and Design, Fabrication and Test; Production: IPPD and the Paladin Enterprise; and Deployment, Operation and Support), and each has TLOs that include how systems engineering is used |

| Hook | SYS 201 | SYS 301 |
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| | integration to optimize total system performance (hardware, software, and human), operational effectiveness, and suitability, survivability, safety, and affordability. PMs shall consider supportability, life cycle costs, performance, and schedule comparable in making program decisions. Planning for Operation and Support and the estimation of total ownership costs shall begin as early as possible. Supportability, a key component of performance, shall be considered throughout the system life cycle." | within that phase |
| In service systems engineering | This hook does not appear to have been explicitly called out in any of the SYS201 A & B lesson materials.<br>***In a search for "in-service" in SYS 201 B: Review Resources:*** Under System Deployed and Post-production in Lesson 20: Product Improvement, there is one section that specifically touches on the in-service issue: "Minor modifications are less costly than major modifications and therefore are handled by each service's In-Service Engineering Agent (ISEA) or the program office if it's a cradle-to-grave program. They utilize systems engineering activities in all of the life cycle phases." In addition, there is the following information on the operation and support phase:<br>• Lesson 1: Systems Acquisition Overview states that RDT&E, production, and operation and support objectives have to all be considered in determining the cost of a program<br>• Under Total Systems Approach in Lesson 3: Systems Engineering: "Planning for Operation and Support and the estimation of total ownership costs shall begin as early as possible. Supportability, a key component of performance, shall be considered throughout the system life cycle." | • The TLO for Lesson 13: Production: IPPD and the Paladin Enterprise, is to "evaluate use of systems engineering process to monitor and control the system configuration, support the production process and control the program cost and schedule." The TLO shows that systems engineering is being taught in conjunction with the Production phase. A slide on p. 170 includes "Functions of the Systems Engineer During Production" and another on p. 176 includes "Test and Evaluation & Systems Engineering." [These will probably be incorporated into the new 201 course that is by phase.]<br>• Lesson 14: Deployment, Operation & Support has a TLO that incorporates the use of systems engineering in that phase. "Given a case study students will be able to: Evaluate use of the systems engineering process to reduce risk of operational/ support problems, as well as to plan and monitor the fielding process."<br>*[These next comments are based on the expanded definition of "in-service" systems engineering from E10]*<br>• Unable to find a reference to "in-service systems engineering" in SYS 301 using the "find" function. |

| Hook | SYS 201 | SYS 301 |
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| | | • *A question—who actually performs "in-service" systems engineering, or SE during deployment? Is it still the responsibility of the system developer (government or contractor?), or does it become the responsibility of the users? Or is it some combination where it is the responsibility of the developer to put in place a mechanism for the system users to do in-service engineering? This hook mentions providing the program manager with information, including "system trends" about the system. Is there a PM once a system is fielded? And are the "system trends" maintenance type trends, or breakdown trends, or performance trends from development? Or trends in technologies for upgrades? Or trends that help determine which parts of the system may wear more than others? Etc.*<br>• Should something about "during all phases of the system lifecycle" be added to the TLO for Lesson 3: System Analysis and Control? The TLO currently reads: "Apply systems analysis and control tools, employing an Integrated Product and Process Development approach to systems engineering management." Or perhaps it could be included in one of this lesson's ELOs? Another place to include these hooks could be in Lesson 14: Deployment, Operation and Support. Or, potentially Lesson 15: Improvements to Existing Weapon Systems.<br>• This hook fits nicely with the robust SE concept<br><u>Monitor experienced system performance and failures</u><br>• "Continue to monitor system performance" is listed as an "Operational Support Objective" on page 197 of Lesson 14: Deployment, Operation & Support<br>• Lesson 3: System Analysis and Control includes Technical Performance Measures (TPMs) but it does |

| Hook | SYS 201 | SYS 301 |
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| | | not specifically mention using them during the deployment/support phase<br>• COSSI (Commercial Operations & Support Savings Initiative) is described in two slides (p. 220) in Lesson 15: Improvements to Existing Weapon Systems. An example about automatic data collection and diagnostics is included.<br>• Lesson 6-03: SW Best Practices includes “Life Cycle Integration” as a best practice on p. 396 (this was extracted from a DSMC presentation called PSM or Practical Software Measurement). The idea behind this practice is that measurement results must be made available at appropriate times in the software lifecycle and that decisions in one phase may have outcomes in other lifecycle phases.<br>• Lesson 6-03: SW Best Practices discusses the use of metrics, but not specifically with respect to deployed software. However, p. 469 does include “Make software measurement an integral part of program management throughout the software life cycle” in a Metrics Summary slide.<br><u>Identify root causes</u><br>• Using the find function, only one reference to the term “root cause” occurs, which is in a worksheet in Lesson 10: System Definition—it did not come up in Lesson 14: Deployment, Operations, & Support, Lesson 15: Improvements to Existing Weapon Systems, or Lesson 3: System Analysis and Control.<br><u>Evaluate risks</u><br>• Risk identification, evaluation, handling is included in Lesson 3, but again, the lesson does not specifically mention doing this in the deployment/support phases of a system’s lifecycle. |

| Hook | SYS 201 | SYS 301 |
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| | | • In Lesson 15: Improvements to Existing Weapon Systems, p. 226 includes a slide suggesting things that a SPRDE Managers need to do. One of the statements is “Be alert for changes that will cause the need to change your system. Involve the User!” That sounds kind of like identifying risks?<br>• Lesson 6-03: SW Best Practices discusses risk management, but not specifically with respect to deployed software (p. 462)<br><u>Provide the PM with integrated technical assessment of system trends, corrective action alternatives, staffing and resource requirements.</u><br>• Charts showing performance measures over the lifecycle of a systems’ development (which could be considered trends) are shown in Lesson 3 (p. 157 has an example), but not really trends in deployment.<br>• In Lesson 15: Improvements to Existing Weapon Systems, p. 226 includes a slide suggesting things that a SPRDE Managers need to do. One of the statements is “Be sure to look carefully at operations and support activities and results from the field to tell when to plan for a system change.” Another is to “use the systems engineering process.”<br>• Lesson 6-01 includes a teaching note, Teaching Note 2, “Post Deployment Software Support” (p. 299-302) that gets into improving the PDSS process. Developing a CRLCMP or Computer Resources Life Cycle Management Plan is one of the actions suggested to improve the process. It “defines criteria for measuring progress” and “identifies the resources needed to acquire, develop, test and support computer resources (e.g., facilities, personnel, hardware, software, training, funding, |

| Hook | SYS 201 | SYS 301 |
|---|---|---|
| | | tools).” It is noted that this plan used be required by DoD policies and while it is no longer required, it is still a best practice. |
| Metrics (added) | A search on the term “metrics” revealed that it is in the SYS 201 B Review Resource text 127 times. The following is a summary of where and how it appears:<br>• Metrics first appears in Lesson 2: Integrated Product and Process Development under the sections, IPPD Principles and Proactive Identification of Management and Risk, where it states: “Technical and business performance measurement plans should be developed, with appropriate metrics, and compared to best-in-class government and industry benchmarks to verify their effectiveness.”; The definition of metrics is also listed as one of nine steps to implementing IPPD for a program; “Metrics are used at all levels of a program’s structure, preferably representing key measures of output rather than input or activity metrics. Many metrics, such as those relating to cost, schedule, and performance (e.g., life cycle costs) can be used throughout the program’s life cycle, while others may be tied to one portion of the program.”; Further mention of metrics also appears in the following sections: IPPD Metrics, Metric Attributes, Metric Development Process, and Metric Guidelines<br>• Under the section on Metrics in Management: Control Criteria in Lesson 6: Systems Engineering Planning it says: “Management of technical activities requires three basic types of metrics: Product metrics that track the development of products, Earned value that tracks conformance to the planned schedule and cost, and Management | • Metrics are discussed throughout SYS 301 in many of the lessons. For example, the TLO for Lesson 6-04: Software Management Exercise is "Given a software intensive system scenario and project ***metrics*** data, conduct an in-depth project performance analysis to assess the project's status, determine problem causes and recommend corrective courses of action.” One of the TLOs is to “Evaluate a set of ***metrics*** for an ongoing program.”<br>• Metrics come up in Lesson 3: System Analysis and Control with respect to RFPs and what they require. (p. 153) They should have key TPMs and program metrics<br>• Overall, “metrics” come up most often in the four software lessons<br>• A teaching note in Lesson 6-01: The DoD Software Acquisition Management Environment mentions using software metrics as a best practice (p. 311)<br>• Another teaching note on quality in Lesson 6-02 also talks about metrics (p. 330). It says that metrics and measurements are needed in order to know if a product has quality attributes (p. 330).<br>• Software management metrics are mentioned later in Lesson 6-02 as a way to examine the status of the software at various intervals. (p. 342)<br>• There is a teaching note devoted to software metrics on p. 381 (lesson 6-03: DoD Software Acquisition Planning and Strategy)<br>• In Lesson 7: Concept and Technology Development, p. 608 includes a slide that says that showing that |

| Hook | SYS 201 | SYS 301 |
| --- | --- | --- |
| | process metrics that track management activities.”; Elsewhere in this lesson, product metrics are equated with systems engineering metrics and describes three types of requirements reflected by product metrics- operational performance, lifecycle suitability, and affordability; In addition it also states that “A key set of systems engineering metrics is TPM.”<br>• Metrics appears under the section on Software Management Metrics in <u>Lesson 10</u>: Verification<br>• Metrics appears under the section on Metrics under During Operational Support in <u>Lesson 15</u>: Cost Containment<br>• In the section on Metrics under Risk Management in <u>Lesson 17</u>: Risk Management, it states: “Early risk planning should also establish risk monitoring metrics. These metrics allow measurement and evaluation of the status of risk-handling options, system performance, cost and schedule.”<br>• Under the section on Product Metrics in <u>Lesson 18</u>: Technical Performance Measurement it states: “A key set of systems engineering metrics are the TPMs. TPMs are product metrics that track design progress toward meeting customer requirements. They are closely associated with the SEP because they directly support traceability of operational needs in the design effort.” Under the section on Timing it further states: “Product metrics which track the development of the product are tied directly to the design process. Planning for metrics should be part of the Systems Engineering Process (SEP) planning effort starting in the early phases of the life cycle.” Furthermore, “The need to track product metrics ends in the production phase, | “metrics for future successful phases [are] defined” is a purpose of a Concept Exploration Work Effort Technical Review.<br>• Lesson 11: Design, Fabrication and Test uses the term “metrics” in a couple of places: first to with respect to preliminary design (p. 132) and then again on a slide about Production Readiness Reviews (p. 139)<br>• “Building a Business Case for Modeling and Simulation,” an article included in Lesson 16: Modeling and Simulation mentions creating metrics as the final step in developing a business case. |

| Hook | SYS 201 | SYS 301 |
|---|---|---|
| | usually concurrent with the establishment of the product (as-built) baseline." | |
| Technical Basis for Cost | • Specific references to the "technical basis for cost" and "cost drivers" do not appear in SYS 201 B: Review Resource. However, the focus on CAIV and Total Ownership Cost in Lesson 15: Cost Containment does appear to capture the intent of this hook. Cost objectives are to be set in an aggressive, yet realistic, manner through cost-performance analyses and trades based upon balancing "mission needs with projected out-year resources, taking into account existing technology, maturation of new technologies and anticipated process improvement in both DoD and industry." Furthermore, these cost objectives are to be established early and updated for each acquisition phase. | • A teaching note on p. 137 of Lesson 3:System Analysis and Control Tools, discusses the need to use Technical Performance Measures (TPMs) to provide visibility into "key elements of the work breakdown structure, especially those which are cost drivers on the program, lie on the critical path, or which represent high risk items."<br>• CAIV is included in Lesson 3: System Analysis and Control Tools.<br>• A slide on p. 162 suggests that a SPRDE manager should use Earned Value as an indicator of cost and risk drivers<br>• Slides on pages 470 and 471 of Lesson 6-03: Software Best Practices include material about cost drivers and cost estimating for software.<br>• Environmental, Safety and Occupational Health (ESOH) cost drivers are listed on pages 17 and 18 of Lesson 8: ESOH |
| Requirements in an Integrated Framework | • Specific references to an "integrated framework" do not appear in SYS 201B. However, with coverage of IPPD, IPTs, and the total systems approach, one may infer that this hook is touched upon. | • "Identify and describe the major ESOH requirements" is one of the ELOs for Lesson 8: ESOH (p. 7)<br>• There is mention of both manufacturing and support requirements in Lesson 11: Design, Fabrication and Test, p. 132.<br>• One of the Logistics objectives listed on p. 194 of Lesson 14: Deployment, Operation and Support, is to "Develop and acquire a system that cost effectively meets the user readiness and support requirements." This lesson's overview states that "[The student] needs a holistic understanding of how |

| Hook | SYS 201 | SYS 301 |
|---|---|---|
| | | requirements fit into the context of the overall systems engineering process, especially those factors relating to equipment life cycle in the DoD environment."<br>• There is also a lesson learned on p. 202 of Lesson 14 that states that "Logistics needs are systems engineering process requirements - not constraints"<br>• The TLO for Lesson 16: Modeling and Simulation is "Identify the modeling & simulation requirements, benefits, pitfalls, planning and applications in systems acquisition."<br>• There is a slide on page 171 in Lesson 3: System Analysis and Control Tools titled "Requirements Flowdown" that covers the need to relate operational requirements from the CDD to system specifications.<br>• "Lack of requirements traceability, ORD ---> Spec": The lack of requirements traceability from the ORD to specs is one of the reasons listed for why systems pass DT&E but fail IOT&E on p. 142 of Lesson 11: Design, Fabrication and Test. |

# Appendix F
# Systems Engineering Topics

## SYSTEMS ENGINEERING TOPICS

IDA created this list of topics from various standards; models; textbooks; and education, training, and certification programs as a tool to support our development of the SPRDE/SE Duties and Tasks list. We developed the tables intending to review the list of Duties and Tasks against them and make sure that we did not miss any important systems engineering topics in the list. This appendix includes six tables of systems engineering topics.

- Standards and Models
- Systems Engineering Textbooks
- Education and Training Programs
- Certification Programs (1)
- Certification Programs (2)
- Certification Programs (3)

All six of the tables are organized according to a general list of systems engineering topics located in the first column of each table. There are typically five or six sources per table. The topics from each source are below the title and are organized according to the general list of topics in the left column. This organization provided a structure to the numerous topics from each source. As a result, however, there are many empty cells in all of the tables. Note that some of the cell entries are followed by an underscore (_) and a number and are highlighted in blue. We used this representation to show that the contents of that cell are mapped to other general topics in the table. For example, "Requirements Validation" from Source #1 may be mapped to both "Requirements Development" and to "Validation" in the left-hand column of the table. In this case, "Requirements Validation_1" would appear in the Source #1 Requirements Development cell, and "Requirements Validation_2" would appear in the Source 1 Validation cell.

## SYSTEMS ENGINEERING TOPICS: STANDARDS AND MODELS

Sources for this table:

- INCOSE SE Book of Knowledge (SEBOK), "Mapping SE Processes into Program Phases," INCOSE Handbook, p. 22, available on SEBOK, available at http://projects.metrostarsystems.com:8080/incose/pal/
- INCOSE SEBOK, SE Competencies, 2.3.3 SE Competencies, available at http://projects.metrostarsystems.com:8080/incose/pal/
- Capability Maturity Model Integration (CMMI), Continuous version updated 2002, available at http://www.sei.cmu.edu/pub/documents/02.reports/pdf/02tr011.pdf
- ISO/EIC 15288, first edition 2002-11-01, International Standard, SE—System life cycle processes
- ANSI/EIA-632-1998, Approved January 7, 1999, International Standard, SE—System life cycle processes
- IEEE Std 1220—1998, International Standard, SE—System life cycle processes

| **Source Title** | **INCOSE SEBOK** "Mapping SE Processes into Program Phases" | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| **SE Process** | | | | | | SE Process (SEP) |
| | | | | | | Policies and procedures for SE |
| Req'ts Development | | Business Processes and Operational Assessment (BPOA) | Engineering: Req'ts Development | Technical Processes: Req'ts Analysis Process | Req'ts Definition Process Req'ts: Acquirer Req'ts | SEP: Req'ts Analysis |

| **Source Title** | **INCOSE SEBOK** “Mapping SE Processes into Program Phases” | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| | Req’ts Analysis: Capture Source Req’ts | Business Processes and Operational Assessment (BPOA): Business & operational shortfalls | | Technical Processes: Stakeholder Req’ts Definition Process | Req’ts Definition Process Req’ts: Other Stakeholder Req’ts | SEP: Req’ts Verification_1 |
| | Req’ts Analysis: Develop Operational Concept | Business Processes and Operational Assessment (BPOA): Solution Req’ts | | | Req’ts Definition Process Req’ts: System Technical Req’ts | |
| | Req’ts Analysis: Functional Performance Req’ts | | | | Solution Definition Process Req’ts: Specified Req’ts | |
| | Req’ts Analysis: Design Constraint Req’ts | | | | | |
| | Req’ts Analysis: Req’ts Allocation | | | | | |
| Req’ts Mgmt | | | Engineering: Req’ts Mgmt | | | |

| Source Title | **INCOSE SEBOK** "Mapping SE Processes into Program Phases" | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| Functional Analysis and Allocation | | System / Solution / Test Architecture (SSTA): Develop functional architecture | | | Solution Definition Process Req'ts: Logical Solution Representations | SEP: Functional Analysis |
| | | System / Solution / Test Architecture (SSTA): Allocate functions to physical elements_1 | | | | SEP: Functional Verification_1 |
| Physical Solution/ Design Synthesis | | System / Solution / Test Architecture (SSTA): Develop physical architecture | Engineering: Technical Solution | Technical Processes: Implementation Process | Solution Definition Process Req'ts: Physical Solutions Representations | SEP: Synthesis |
| | System Architecture Synthesis: Synthesize Multiple Architectures | System / Solution / Test Architecture (SSTA): Allocate functions to physical elements_2 | | Technical Processes: Architectural Design Process | Implementation Process Req'ts: Implementation | Development Strategies |

| Source Title | **INCOSE SEBOK** “Mapping SE Processes into Program Phases” | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| | System Architecture Synthesis: System Element Req’ts | System Implementation Support | | | System Verification Process Req’ts: Design Solution Verification_1 | |
| | System Architecture Synthesis: Eval/Select Pfd. Architecture | | | | | |
| | System Architecture Synthesis: Integrated Sys. Physical Config. | | | | | |
| | System Architecture Synthesis: Define/Refine Interfaces_1 | | | | | |
| | System Architecture Synthesis: Develop Spec. Trees & Specs. | | | | | |
| Systems Analysis | Systems Analysis | Modeling, Simulation, & Analysis (MS&A) | Support: Measurement and Analysis | | Systems Analysis Process Req’ts: Effectiveness Analysis | SEP: Systems Analysis |

| **Source Title** | **INCOSE SEBOK** “Mapping SE Processes into Program Phases” | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| | | MS&A: Conduct system performance modeling and forecasting | Support: Causal Analysis and Resolution | | | SEP: Control |
| | | MS&A: Conduct system architecture modeling and analysis | | | | |
| | Systems Analysis: Tradeoff studies | | | | Systems Analysis Process Req’ts: Tradeoff Analysis | |
| | Systems Analysis: System Modeling & Simulation | | | | | Modeling and Prototyping_1 |
| *Integration* | System Implementation Support: System Integration | | Engineering: Product Integration | Technical Processes: Integration Process | | |
| | | | Support: Organizational Environment for Integration_1 | | | |

| **Source Title** | **INCOSE SEBOK** "Mapping SE Processes into Program Phases" | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| Verification | System Implementation Support: System Verification | | Engineering: Verification | Technical Processes: Verification Process | System Verification Process Req'ts: Design Solution Verification_2 | SEP: Req'ts Verification_2 |
| | | | | | System Verification Process Req'ts: End Product Verification | SEP: Functional Verification_2 |
| | | | | | System Verification Process Req'ts: Enabling Product Readiness | SEP: Design Verification |
| Validation | | | Engineering: Validation | Technical Processes: Validation Process | Req'ts Validation Process Req'ts: Requirement Statements Validation | |
| | | | | | Req'ts Validation Process Req'ts: Acquirer Req'ts Validation | |
| | | | | | Req'ts Validation Process Req'ts: Other Stakeholder Req'ts Validation | |

| Source Title | **INCOSE SEBOK** "Mapping SE Processes into Program Phases" | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| | | | | | Req'ts Validation Process Req'ts: Logical Solution Representations Validation | |
| | | | | | End Products Validation Process Req'ts: End Products Validation | |
| **SE Mgmt** | | | Project Mgmt: Quantitative Project Mgmt | Enterprise Processes: System Life Cycle Processes Mgmt Process | | |
| | | | | Enterprise Processes: Resource Mgmt Process | | |
| SE Process Environment | | | Support: Organizational Environment for Integration_2 | Enterprise Processes: Enterprise Environment Mgmt Process | Planning Process Req'ts: Schedule and Organization_1 | |
| SE Planning and Strategy | | Mgmt: Risk, Configuration, Baseline (Mgt): Tailor SE process | Project Mgmt: Project Planning | Project Processes: Project Planning Process | Planning Process Req'ts: Process Implementation Strategy | Planning the technical effort: Master Schedule |

| **Source Title** | **INCOSE SEBOK** “Mapping SE Processes into Program Phases” | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| | | | Support: Decision Analysis and Resolution | Project Processes: Decision-making Process | Planning Process Req’ts: Technical Effort Definition | Planning the technical effort: Detail Schedule |
| | | | | | Planning Process Req’ts: Schedule and Organization_2 | Planning the technical effort: Technical Plans |
| | | | | | Planning Process Req’ts: Work Directives | System Breakdown Structure |
| | SE Process Control: SEMP, SEMS/SEDS, TPM, Audits_1 | | | | Planning Process Req’ts: Technical Plans | Planning the technical effort: Engineering Plan |
| Risk Mgmt | System Analysis: Risk Mgmt | Mgmt: Risk, Configuration, Baseline (Mgt): Conduct risk Mgmt | Project Mgmt: Risk Mgmt | Project Processes: Risk Mgmt Process | Systems Analysis Process Req’ts: Risk Analysis | |
| | | Mgmt: Risk, Configuration, Baseline (Mgt): Manage key drivers | | | | |

| **Source Title** | **INCOSE SEBOK** "Mapping SE Processes into Program Phases" | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| Configuration Mgmt | SE Product Control | Mgmt: Risk, Configuration, Baseline (Mgt): Perform system configuration Mgmt | Support: Configuration Mgmt | Project Processes: Configuration Mgmt Process | | |
| | System Implementation Support: Baseline Maintenance | | | | | |
| Data Mgmt | | | | Project Processes: Information Mgmt Process | Control Process Req'ts: Information Dissemination | Integrated Database: Data and Schema |
| | | | | | | Integrated Database: Tools |
| | | | | | | Integrated Data Package: Hardware |
| | | | | | | Integrated Data Package: Software |
| | | | | | | Integrated Data Package: Lifecycle Processes |
| | | | | | | Integrated Data Package: Human |

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|---|---|---|---|---|---|---|
| Interface Mgmt | System Architecture Synthesis: Define/Refine Interfaces_2 | System / Solution / Test Architecture (SSTA): Develop interface architecture | | | | |
| | | MS&A: Conduct system user interface analysis_1 | | | | |
| Manufacturing Readiness Levels | | System / Solution / Test Architecture (SSTA): Develop the manufacturing system architecture | | | | |
| Cost Analysis | System Analysis: Life Cycle Cost Analysis | Life Cycle Cost & Cost Benefit Analysis (LCC & CBA) | | | | |
| | | Life Cycle Cost & Cost Benefit Analysis (LCC & CBA): Perform activity-based costing | | | | |

| **Source Title** | **INCOSE SEBOK** "Mapping SE Processes into Program Phases" | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| | | Life Cycle Cost & Cost Benefit Analysis (LCC & CBA): Conduct life cycle costing | | | | |
| | | Life Cycle Cost & Cost Benefit Analysis (LCC & CBA): Conduct cost benefit analyses of the system engineering process | | | | |
| | | Life Cycle Cost & Cost Benefit Analysis (LCC & CBA): Understand the system cost drivers | | | | |
| | | Life Cycle Cost & Cost Benefit Analysis (LCC & CBA): Estimate total ownership cost | | | | |

| Source Title | INCOSE SEBOK "Mapping SE Processes into Program Phases" | INCOSE SEBOK SE Competencies | CMMI | ISO/EIC 15288, first edition 2002-11-01 | ANSI/EIA-632-1998 | IEEE Std 1220-1998 |
|---|---|---|---|---|---|---|
| | System Analysis: Cost and Effectiveness Analysis | | | | | |
| **DoD Acquisition Related Topics** | | | | Agreement Processes: Acquisition Process | Acquisition Process Req'ts: Product Acquisition | |
| | | | | Agreement Processes: Supply Process | Supply Process: Product Supply | |
| Technical Inputs to RFP | Pre-proposal activities: Mission, SRD, SOW, RFP, CDRL | | | | | |
| | | | | | Acquisition Process Req'ts: Supplier Performance | |
| | | | Project Mgmt: Supplier Agreement Mgmt | | | |
| | | | Project Mgmt: Integrated Supplier Mgmt | | | |

| Source Title | **INCOSE SEBOK** “Mapping SE Processes into Program Phases” | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| Technical Reviews amd Audits | SE Process Control: SEMP, SEMS/SEDS, TPM, Audits_2 | | Project Mgmt: Project Monitoring and Control | Project Processes: Project Assessment Process | Assessment Process Req’ts: Progress Against Plans and Schedules | Technical Reviews |
| | | | | Project Processes: Project Control Process | Assessment Process Req’ts: Progress Against Req’ts | |
| | | | | | Assessment Process Req’ts: Technical Reviews | |
| **SE Enablers** | | | | | | |
| IPPD | | | Project Mgmt: Integrated Teaming | | | Integration of the SE effort: Integrated Teams |
| | | | | Project Mgmt: Integrated Project Mgmt for IPPD | | Product and Process Improvement: Re-engineering |
| | | | | | | Product and Process Improvement: Self Assessment |

| **Source Title** | **INCOSE SEBOK** "Mapping SE Processes into Program Phases" | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| | | | | | | Product and Process Improvement: Lessons Learned |
| Prototyping | | | | | | Modeling and Prototyping_2 |
| **SE Design Considerations** | | | | | | |
| Training | | System / Solution / Test Architecture (SSTA): Develop the training system architecture | | | | |
| Reliability, Availability, Maintainability | | | | Technical Processes: Maintenance Process | | |
| Test and Evaluation | | System / Solution / Test Architecture (SSTA): Develop test system architecture | | | | |

| Source Title | **INCOSE SEBOK** "Mapping SE Processes into Program Phases" | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| Sustainability | System Implementation Support: Sustaining Engineering | | | | | |
| Disposal and Demilitarization Considerations | | | | Technical Processes: Disposal Process | | |
| Quality | | | Support: Process and Product Quality Assurance | Enterprise Processes: Quality Mgmt Process | | Quality Mgmt |
| Supportability/ Acquisition Logistics | | | | Technical Processes: Operation Process | | |
| | | Serviceability / Logistics (S/L): Develop system supply support and spares Mgmt | | | | |
| | | Serviceability / Logistics (S/L): Analyze system operational and servicing skill Req'ts | | | | |

| **Source Title** | **INCOSE SEBOK** “Mapping SE Processes into Program Phases” | **INCOSE SEBOK** SE Competencies | **CMMI** | **ISO/EIC 15288, first edition 2002-11-01** | **ANSI/EIA-632-1998** | **IEEE Std 1220-1998** |
|---|---|---|---|---|---|---|
| | | Serviceability / Logistics (S/L): Develop system and platform documentation | | | | |
| Human Systems Integration | | MS&A: Conduct system user interface analysis_2 | | | | |
| **Other** | | | | Enterprise Processes: Investment Mgmt Process | Transition to Use Process Req’ts: Transition to Use | Integration of the SE effort: Concurrent Engineering |
| | | | | | Control Process Req’ts: Outcomes Mgmt | Specification Tree |
| | | | | | | Drawing Tree |

## SE TOPICS: SE TEXTBOOKS

Sources for this table:

- Engineering Design Process, Priest
- Systems Engineering and Analysis, Blanchard and Fabrycky
- Engineering Complex Systems with Models and Objects, David Oliver, Timothy P. Kelliher, and James G. Keegan, Jr.
- The Engineering Design of Systems, Dennis Buede
- Introduction to SE, Sage and Armstrong

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| **SE Process** | | | Core Technical Process: Process, Methodology and Tools | | |
| | | | Core Technical Process: Product Life Cycle, Acquisition, SE Process | | |
| | | | Core Technical Process: The SE Process Model | | |
| | | | Core Technical Process: Hierarchy, Waterfall, Top Down Development | | |

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| | | | Core Technical Process: Union of Best Practice with Modeling | | |
| Req'ts Development | Req'ts Definition: Market Research and Analysis | Conceptual System Design: Identification of a Need | Assess Available Information: A Req'ts Taxonomy | Develop operational concept | Req'ts and Specifications |
| | Req'ts Definition: Customer Req'ts and needs | Conceptual System Design: System Req'ts Analysis | Assess Available Information: A "Behavior" for Assess Available Information [this refers to the process used to Assess Available Information. It includes: gathering heritage information, gathering user information, gathering text Req'ts information, gathering Ops Concept Information, etc). | Define system boundary with external systems diagram | **Formulation:** Problem Definition |
| | Req'ts Definition: System Req'ts, including producibility and reliability_1 | Conceptual System Design: System Specification | Define Effectiveness Measures | Develop system objectives hierarchy | **Formulation:** Value System Design |
| | *Conceptual Design:* System specifications | Preliminary System Design: Req'ts Allocation_1 | | Develop, analyze and refine Req'ts (originating and system) | |

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| | *Conceptual Design:* Design Req'ts | Preliminary System Design: Design Req'ts (Parameters) | | Ensure Req'ts feasibility | |
| | *Conceptual Design:* Design guidelines | System Test and Evaluation: Req'ts for Test and Evaluation_1 | | Define the test system Req'ts_1 | |
| | *Conceptual Design:* Design to cost_1 | | | | |
| | Detailed Design: Detailed design specifications_1 | | | | |
| Req'ts Mgmt | | Preliminary System Design: Req'ts Allocation_2 | | Req'ts Mgmt | |
| Functional Analysis and Allocation | Conceptual Design: Functional Allocation | Conceptual System Design: Functional Analysis and Allocation | Basics of Behavior [refers to behavior modeling, E.g., Functional Flow Block Diagrams, Data Flow Diagrams, Representation of Behavior as State, Information Model for Behavior, Relationship of Behavior and Structure] | Functional Architecture Development | Functional Decomposition and Functional Analysis |

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| | | Preliminary System Design: Req'ts Allocation_3 | Create a Behavior Model | | Functional Analysis and Business Process Reengineering |
| | | Preliminary System Design: Subsystem Functional Analysis | | | |
| Physical Solution/ Design Synthesis | Detailed Design: Detailed design specifications_2 | Conceptual System Design: Synthesis, Analysis, and Evaluation_1 | Basics of Structure [E.g., Objects and Classes, Aggregation, Cardinality, Interconnection of Objects, Allocation of Functions to Objects] | Physical Architecture Development | Prelimary Conceptual Design and System Architecting |
| | Detailed Design: Circuit design, parts selection, component design, part qualification, mechanical design, thermal design (combination of many topics) | Preliminary System Design: Synthesis and Design Definition | Create a Structure Model | Operational Architecture Development | **Formulation:** System Synthesis |
| | Detailed Design: Package design | Detail Design and Development: Design Engineering Activities | | Interface Design_2 | Detailed Design, Production, and Testing_1 |

| Source Title | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| | Detailed Design: Design to cost | Detail Design and Development: System Prototype Development | | | Logical Design and Product Architectural Specifications |
| | Detailed Design: Documentation | | | | |
| Systems Analysis | Detailed Design: Analysis, modeling, simulation, and prototypes_1 | Conceptual System Design: Synthesis, Analysis, and Evaluation_2 | Concept Analysis | Graphical Modeling Techniques | **Analysis:** Refinement of the Alternatives |
| | Detailed Design: Make or buy analysis | Conceptual System Design: Conceptual Design Review_1 | System Analysis | | Quality Function Deployment |
| | | Optimization in Design and Operations | Subsystem Analysis | | Feasibility Studies |
| | | Control Concepts and Techniques | | | Analysis of Systems with Uncertain and Imperfect Information |
| | | | | | Structural Modeling: Trees, Causal Loops, Influence Diagrams |

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| | | | | | System Dynamics Models and Extensions |
| | | | | | Discrete Event Models |
| Tradeoff Studies | Conceptual Design: Trade studies | | Perform Trade-off Analyses | Decision Analysis for Design Trades | |
| M&S | Conceptual Design: Simulation and modeling | | | | **Analysis:** System Analysis and Modeling |
| | Detailed Design: Analysis, modeling, simulation, and prototypes_2 | | | | |
| Technical Performance Measures | | Conceptual System Design: Technical Performance Measures (TPM) | | | |
| Integration | | Detail Design and Development: Integrating System Elements | | Integration and Qualification | |
| **SE Mgmt** | | | Interface with Acquisition and Mgmt_1 | | SE Methods for SE Mgmt |

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| | | | | | Pragmatics of Systems Mgmt |
| SE Process Environment | | SE Planning and Organization: Organization for SE | | | SE Organizational Structures |
| | | Program Mgmt and Control: Organization Goals and Objectives | | | |
| SE Planning and Strategy | Conceptual Design: Program plans | Conceptual System Design: Accomplishment of Feasibility Analysis | Create Build and Test Plan_1 | | Human and Cognitive Factors in SE and Systems Mgmt_1 |
| | | Conceptual System Design: Advanced System Planning | | | **Interpretation:** Decision Making |
| | | Alternatives and Models in Decision Making | | | **Interpretation:** Planning for Action |
| | | SE Planning and Organization: SE Planning | | | Formal Decisions |
| | | Program Mgmt and Control: Direction and Control of Program Activities | | | Group Decision Making and Voting |

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| SEMP (SE "Master" Plan) | | SE Planning and Organization: SE Mgmt Plan (SEMP) | Create Build and Test Plan_2 | | |
| Risk Mgmt | | Program Mgmt and Control: Program Risk Mgmt | | | |
| Interface Mgmt | | | | Interface Design_2 | |
| Cost Analysis | *Conceptual Design:* Design to cost_2 | Models for Economic Evaluation | | | Economic Models and Economic System Analysis |
| Lifecycle Cost Analysis | | Design for Affordability: Introduction to Life Cycle Costing | | | |
| | | Design for Affordability: Cost Emphasis in the System Life Cycle | | | |
| | | Design for Affordability: The Life Cycle Cost Analysis Process | | | |
| **DoD Acquisition Related Topics** | | | Interface with Acquisition and Mgmt_2 | | |

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| Technology Insertion Mgmt | Detailed Design: Off-line maturing of new technologies | Preliminary System Design: Engineering Design Technologies | | | |
| Technical Reviews and Audits | | Preliminary System Design: System Design Reviews | | | |
| | | Detail Design and Development: Detail Design Reviews | | | |
| | | Conceptual System Design: Conceptual Design Review_2 | | | |
| **SE Enablers** | | | | | |
| Software Design and Development | Detailed Design: Software design | | | | |
| Prototyping | Detailed Design: Analysis, modeling, simulation, and prototypes_3 | | | | |
| **SE Design Considerations** | | | | | |

| Source Title | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| Reliability, Availability, Maintainability | Req’ts Definition: System Req’ts, including producibility and reliability_2 | Design for Reliability | | | Operational Functioning and Maintenance |
| | | Design for Maintainability | | | Reliability, Availability, Maintainability, and Supportability Models_1 |
| Test and Evaluation | Detailed Design: Testability | System Test and Evaluation: Req’ts for Test and Evaluation_2 | | Define the test system Req’ts_2 | Detailed Design, Production, and Testing_2 |
| | Detailed Design: Test planning | System Test and Evaluation: Categories of System/ Component Testing | | | Operational Test and Evaluation |
| | Test and Evaluation (with subtopics) | System Test and Evaluation: Planning for Test and Evaluation | | | |
| | | System Test and Evaluation: Preparing for Test and Evaluation | | | |

| Source Title | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| | | System Test and Evaluation: Test Performance and Reporting | | | |
| | | Design for Producibility and Disposability_1 | | | |
| Producability & Manufacturability | Detailed Design: Production engineering | | | | Detailed Design, Production, and Testing_3 |
| | Detailed Design: Manufacturing planning | | | | |
| | Detailed Design: Producibility | | | | |
| Sustainability | Production and Sustaining Engineering (with subtopics) | | | | |
| Disposal and Demilitarization Considerations | | Design for Producibility and Disposability_2 | | | |
| Quality | Detailed Design: Quality engineering | | | | |

| **Source Title** | **Engineering Design Process,** Priest | **Systems Engineering and Analysis,** Blanchard and Fabrycky | **Engineering Complex Systems with Models and Objects,** David Oliver, et. al. | **The Engineering Design of Systems,** Buede | **Introduction to SE,** Sage and Armstrong |
|---|---|---|---|---|---|
| | Detailed Design: Quality specifications | | | | |
| Supportability/ Acquisition Logistics | Detailed Design: Logistics engineering | Design for Supportability | | | Operational Implementation |
| | | | | | Reliability, Availability, Maintainability, and Supportability Models_2 |
| ESOH | Detailed Design: Safety engineering | | | | |
| | Detailed Design: Environmental testing | | | | |
| Human Systems Integration | Detailed Design: Human engineering | Design for Usability (Human Factors) | | | Human and Cognitive Factors in SE and Systems Mgmt_2 |
| **Other** | | Detail Design and Development: Detail Design Aids | Hand-off (refers to transition between system design and design work b individual engineering disciplines/suppliers) | Obtain approval of system documentation | |

## SE TOPICS: EDUCATION AND TRAINING PROGRAMS

Sources for this table:

- DAU SPRDE SYS 201A
- DAU SPRDE SYS 201B
- DAU ASPRDEC SYS 301
- Boeing Commercial Sources Database
- The National Cryptologic School's SE Training Program, Program Recommendations, Final Release, 12 February 2003
- IBM Req'ts, For purposes of mapping to Academic Courses

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| **SE Process** | Systems Engineering | SE Process Outputs | | | Introduction to SE | SE and Architecture Overview: Define SE and Architecture |
| | SE Process Outputs | | | | Introduction to SE: working definition of SE | SE and Architecture Overview: Define the value of SEA to a project |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | | Introduction to SE: design | SE and Architecture Overview: Summarize the key elements of the SEA methodology |
| | | | | | | SE and Architecture Overview: Clarify and explain relationship between the SEA methodology and other processes, including BTOP |
| | | | | | | SE and Architecture Overview: Clarify and explain relationship between the SEA methodology and development models such as the waterfall and spiral models_1 |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | | | SE and Architecture Overview: Explain the SEA roles and responsibilities and integration with other organizations throughout the project life cycle |
| | | | | | | SE and Architecture Overview: Instruct the SEA work products (deliverables) |
| | | | | | | System Engineering Architecture Method: Instruct the complex problem solving process; concept of system design, analysis, and evaluation |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req’ts |
|---|---|---|---|---|---|---|
| Req’ts Development | Req’ts Analysis | Req’ts Analysis | | Business Processes and Operational Assessment: Business & operational shortfalls | Introduction to SE: conceptual development | SE Architecture Req’ts: Distinguish between Req’ts (whats) and designs (hows) |
| | | | | Business Processes and Operational Assessment: Solution Req’ts | Req’ts: translating customer needs and priorities into an operational concept and then into traceable functional and system performance Req’ts | SE Architecture Req’ts: Define the characteristics of a requirement |
| | | | | Business Processes and Operational Assessment: Analysis of time to market Req’ts | | SE Architecture Req’ts: Define the types of Req’ts |
| | | | | Business Processes and Operational Assessment: Analysis of product platform alternatives | | SE Architecture Req’ts: Define the types and characteristics of Req’ts documents |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | Business Processes and Operational Assessment: Analysis of cost Req'ts_1 | | SE Architecture Req'ts: Instruct the integration of SEA Req'ts documents with other project documents (documentation tree)_1 |
| | | | | Business Processes and Operational Assessment: Analysis of behavioral Req'ts | | SE Architecture Req'ts: Instruct the Req'ts development method |
| | | | | Business Processes and Operational Assessment: Identify what is achievable within the cost, schedule and technical envelope | | SE Architecture Req'ts: Instruct the Req'ts decomposition method |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | System, Solution, Test Architecture: Develop Req'ts | | SE Architecture Req'ts: Student activity to exercise the SEA Req'ts definition methodology to create an unambiguous, testable, and traceable set of Req'ts |
| | | | | | | System Engineering Architecture Method: Instruct the method to determine the customer's operational needs |
| | | | | | | System Engineering Architecture Method: Instruct the method to gather customer Req'ts (6, 7) |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | | | System Engineering Architecture Method: Instruct the method to allocate Req'ts to functional and physical components _1 |
| Req'ts Mgmt | | | | Mgmt: Risk, Configuration, Baseline: Perform Req'ts Mgmt | | System Engineering Architecture Method: Instruct method to establish & manage a Req'ts baseline |
| | | | | Business Processes and Operational Assessment: Identify and manage solution functional and operational baselines | | SE Architecture Req'ts: Instruct the SEA Req'ts Mgmt methodology/tools |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req’ts |
|---|---|---|---|---|---|---|
| Functional Analysis and Allocation | Functional Analysis and Allocation | Functional Analysis and Allocation | | System, Solution, Test Architecture: Develop functional architecture | Architecture and Design: allocation of functions to meet Req’ts | System Engineering Architecture Method: Instruct system functional analysis; integration of system operational and support functions; discussion of related methods (FFBDs, IDEFs, N-Squared Charts) |
| | | | | System, Solution, Test Architecture: Allocate functions to physical elements_1 | | System Engineering Architecture Method: Instruct the concept of system packaging; system architecture; allocation of system-level Req’ts to conceptual sub-systems |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | | | System Engineering Architecture Method: Instruct the method to allocate Req'ts to functional and physical components _2 |
| Physical Solution/ Design Synthesis | Synthesis | Synthesis | | System, Solution, Test Architecture: Develop physical architecture | Architecture and Design: systems architecture/synth esis | System Engineering Architecture Method: Instruct system architecture development |
| | | | | System, Solution, Test Architecture: Allocate functions to physical elements_2 | Architecture and Design: arrangement of element, subsystems and systems | System Engineering Architecture Method: Instruct the method to allocate Req'ts to functional and physical components _3 |
| | | | | | Architecture and Design: systems architecting process | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| Systems Analysis | | | System Analysis and Control Tools | | | System Engineering Architecture Method: Instruct the concept of system operational effectiveness (SOE), and the "cause-and-effect" analysis between design, and system operation and support |
| | | | | | | System Engineering Architecture Method: Instruct system architecture evaluation |
| Tradeoff Studies | Trade Studies | Trade Studies | | System, Solution, Test Architecture: Perform trade studies | | System Engineering Architecture Method: Instruct the method to conduct trade studies |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
| --- | --- | --- | --- | --- | --- | --- |
| M&S | | | M&S | Modeling, Simulation, and Analysis: Conduct system performance modeling and forecasting | | |
| | | | | Modeling, Simulation, and Analysis: Conduct system architecture modeling and analysis | | |
| | | | | Modeling, Simulation, and Analysis: Conduct operations analysis | | |
| | | | | Modeling, Simulation, and Analysis: Conduct system reliability, availability and maintainability analysis_1 | | |
| | | | | Modeling, Simulation, and Analysis: Conduct system safety analysis _1 | | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | Modeling, Simulation, and Analysis: Conduct system user interface analysis_1 | | |
| Technical Performance Measures | Technical Performance Measurement | Technical Performance Measurement | | Mgmt: Risk, Configuration, Baseline: Manage technical performance measure variances | | SE and Architecture Overview: Instruct the SEA metrics and technical performance measures |
| Integration | | | | Mgmt: Risk, Configuration, Baseline: Conduct system integration | Integration: interfaces between the elements_1 | System Engineering Architecture Method: Instruct integration with: Test methods and procedures; software development method; service delivery and Mgmt method |
| | | | | | Integration: test, verification, validation_1 | |

| **Source Title** | **DAU SPRDE SYS 201A** | **DAU SPRDE SYS 201B** | **DAU ASPRDEC 301** | **Boeing** | **National Cryptologic School** | **IBM Req'ts** |
|---|---|---|---|---|---|---|
| Verification | Verification | | | Mgmt: Risk, Configuration, Baseline: Conduct verification | | |
| Validation | | | | Mgmt: Risk, Configuration, Baseline: Conduct validation | Integration: test, verification, validation_2 | |
| **SE Mgmt** | | | | Mgmt: Risk, Configuration, Baseline: Manage schedule variances | Introduction to SE: organization and Mgmt of complex systems_1 | |
| SE Process Environment | | | | Mgmt: Risk, Configuration, Baseline: Create the SE organization | Project Mgmt for Systems Engineers: SE organization | SE and Architecture Overview: Instruct the typical SEA project staffing model |
| | | | | Mgmt: Risk, Configuration, Baseline: Create and manage SE teams | Introduction to SE: roles and responsibilities | |
| | | | | | Project Mgmt for Systems Engineers: roles and responsibilities | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | | Introduction to SE: organization and Mgmt of complex systems_2 | |
| SE Planning and Strategy | SE Planning | | | Business Processes and Operational Assessment: Design the acquisition process | Project Mgmt for Systems Engineers: planning | System Engineering Architecture Method: Instruct the method to enable technical planning and Mgmt |
| | | | | Mgmt: Risk, Configuration, Baseline: Develop and manage processes | Project Mgmt for Systems Engineers: scheduling | SE and Architecture Overview: Summarize the plan for SEA training and professional development_1 |
| | | | | Mgmt: Risk, Configuration, Baseline: Define the SE process | Project Mgmt for Systems Engineers: resource mgmt | System Engineering Architecture Method: Instruct the method to enable capacity planning_1 |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | Mgmt: Risk, Configuration, Baseline: Develop plans and schedules | Project Mgmt for Systems Engineers: process development | |
| | | | | Mgmt: Risk, Configuration, Baseline: Tailor SE process | | |
| Work Breakdown Structure (WBS) | Work Breakdown Structure (WBS) | Work Breakdown Structure (WBS) | | | | |
| SEMP (SE "Master" Plan) | | | | | | SE Architecture Req'ts: Instruct the integration of SEA Req'ts documents with other project documents (documentation tree)_2 |
| Risk Mgmt | Risk Mgmt | Risk Mgmt | | Mgmt: Risk, Configuration, Baseline: Conduct risk Mgmt | Risk Mgmt: risk definition | |
| | | | | Mgmt: Risk, Configuration, Baseline: Manage key drivers | Risk Mgmts: subsequent identification, assessment, and Mgmt | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| Configuration Mgmt | Config. Mgmt | Config. Mgmt | | Mgmt: Risk, Configuration, Baseline: Perform system configuration Mgmt | | |
| Interface Mgmt | | | | System, Solution, Test Architecture: Develop interface architecture | Integration: interfaces between the elements_2 | |
| | | | | System, Solution, Test Architecture: Develop other system interface architecture | | |
| | | | | Modeling, Simulation, and Analysis: Conduct system user interface analysis_2 | | |
| Manufacturing Readiness Levels | | | | System, Solution, Test Architecture: Develop the manufacturing system architecture | | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| Cost Analysis | | | | Mgmt: Risk, Configuration, Baseline: Manage cost variances | Engineering Economics: cost-benefit analysis | |
| | | | | Business Processes and Operational Assessment: Analysis of cost Req'ts_2 | Engineering Economics: introductory level accounting | |
| | | | | | Engineering Economics: budget fundamentals | |
| Lifecycle Cost Analysis | | | | | Engineering Economics: life-cycle cost estimation | System Engineering Architecture Method: Instruct system life cycle analysis and life cycle costing |
| Technical Basis for Cost | Cost Containment | | | | | |
| **DoD Acquisition Related Topics** | Systems Acquisition Overview | | Acquisition Policy and the Resource Allocation Process | | | |
| Source Selection Planning | Solicitations and Source Selection | Solicitations and Source Selection | | | | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| Architecture Frameworks | | | Architecture and Interoperability (from TOC)/ Interoperability and Architecture (from Lesson Assignment Sheet) | System, Solution, Test Architecture: Determine and manage impact to current fielded solutions | | System Engineering Architecture Method: Instruct the method to define an architecture |
| | | | | | | System Engineering Architecture Method: Instruct the method to enable capacity planning_2 |
| Technology Insertion Mgmt | Technology Develop-ment and Insertion | | Technology Mgmt | Mgmt: Risk, Configuration, Baseline: Analyze technology insertion and refreshment | | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req’ts |
|---|---|---|---|---|---|---|
| Technical Reviews amd Audits | Technical Reviews | | | Mgmt: Risk, Configuration, Baseline: Monitor and control of a project | | SE and Architecture Overview: Define the basic content and conduct of a System Req’ts Review (SRR), Preliminary Design Review (PDR), and Critical Design Review (CDR) |
| | | | | | | System Engineering Architecture Method: Instruct the method to conduct a System Req’ts Review (SRR) |
| | | | | | | System Engineering Architecture Method: Instruct the method to conduct a Preliminary Design Review (PDR) |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | | | System Engineering Architecture Method: Instruct the method to conduct a Critical Design Review (CDR) |
| Metrics | | | | | | System Engineering Architecture Method: Instruct the establishment and Mgmt of SEA metrics and Technical Performance Measures (TPMs) |
| **SE Enablers** | | | | | | |
| Process Models and Standards | | | | | Introduction to SE: intro to common SE models | SE and Architecture Overview: Instruct compliance with SEI-CMM |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | | Introduction to SE: project lifecycles | SE and Architecture Overview: Clarify and explain relationship between the SEA methodology and development models such as the waterfall and spiral models_2 |
| Software Design and Development | | | DoD Software Acquisition Planning and Strategy (from TOC)/ The DoD Software Acquisition Mgmt Environment (from Lesson Assignment Sheet) | | | |
| | | | DoD Software Acquisition Control and Methodology (from TOC)/ SW Engineering Process (from Lesson Assignment Sheet) | | | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | DoD Software Acquisition Planning and Strategy (from TOC)/ SW Best Practices (from Lesson Assignment Sheet) | | | |
| | | | Software Mgmt Exercise (Case Scenario and Workshop) | | | |
| IPPD | Integrated Product and Process Development | Integrated Product and Process Development | Integrated Product and Process Development | | | |
| | Product Improvement | Product Improvement | Production: IPPD and the Paladin Enterprise_1 | | | |
| **SE Design Considerations** | | | | | | |
| Training | | | | System, Solution, Test Architecture: Develop the training system architecture | | SE and Architecture Overview: Summarize the plan for SEA training and professional development_2 |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | Serviceability, Logistics: Develop system training_1 | | |
| Reliability, Availability, Maintain-ability | | | | Modeling, Simulation, and Analysis: Conduct system reliability, availability and maintainability analysis_2 | Reliability and Maintainability: how to develop a systems architecture, from conceptual design onward, that meets the user's reliability and maintainability concerns | |
| | | | | Serviceability, Logistics: Develop system maintenance concept_1 | | |
| Test and Evaluation | | | | System, Solution, Test Architecture: Develop test system architecture (functional, physical and interface) | Integration: test, verification, validation_3 | |
| Producability & Manufactur-ability | | | Production: IPPD and the Paladin Enterprise_2 | | | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| Sustainability | | | Deployment, Operation and Support_1 | | | |
| Supportability/ Acquisition Logistics | | | Deployment, Operation and Support_2 | System, Solution, Test Architecture: Develop the deployment system architecture | Logistics and Supportability | |
| | | | | Serviceability, Logistics: Develop system maintenance concept_2 | | |
| | | | | Serviceability, Logistics: Develop system supply support and spares Mgmt | | |
| | | | | Serviceability, Logistics: Analyze system operational and servicing skill Req'ts | | |
| | | | | Serviceability, Logistics: Develop system and platform documentation | | |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | | Serviceability, Logistics: Develop system training_2 | | |
| ESOH | Environ-mental, Safety and Health | | Environmental, Safety, and Occupational Health | | | |
| Human Systems Integration | | | | System, Solution, Test Architecture: Develop user / operator / maintainer interface architectures | | |
| Safety and Security | | | | Modeling, Simulation, and Analysis: Conduct system safety analysis _2 | | |
| **Other** | | Admin | Concept and Technology Development | Mgmt: Risk, Configuration, Baseline: Select the SE tools | | System Engineering Architecture Method: Provide a complex system development case study and "lessons learned" |

| Source Title | DAU SPRDE SYS 201A | DAU SPRDE SYS 201B | DAU ASPRDEC 301 | Boeing | National Cryptologic School | IBM Req'ts |
|---|---|---|---|---|---|---|
| | | | Benefits and Challenges of International Cooperation | | | |
| | | | System Definition | | | |
| | | | Design, Fabrication and Test | | | |
| | | | Current Events and Issues | | | |
| | | | Improvements to Existing Weapon Systems | | | |
| | | | Professional Ethics Case | | | |

## SE TOPICS: CERTIFICATION PROGRAMS (1)

Sources for this table:

- Aerospace Corporation/ Aerospace Initiative
- California Institute of Technology (Cal Tech)
- INCOSE
- Massachusetts Institute of Technology (MIT)
- Naval Post Graduate School
- Portland State University

| Source Information | Aerospace Corporation | Cal Tech | INCOSE | MIT | Naval Post Graduate School | Portland State U. |
|---|---|---|---|---|---|---|
| **SE Process** | SE | Understanding Systems and SE | General SE Knowledge | SE Methods | SE and Architecture_1 | SE Approach |
| Req'ts Development | | Constructing SE Req'ts | Req'ts and Architecture Definition_1 | | | |
| | | | Req'ts Engineering | | | |
| Functional Analysis and Allocation | | Performing a Functional Analysis | | | | |
| Physical Solution/ Design Synthesis | | Developing a systems architecture | | System Architecture | | |
| | | Performing System Design and Development | | System Behaviors | | |

| **Source Information** | **Aerospace Corporation** | **Cal Tech** | **INCOSE** | **MIT** | **Naval Post Graduate School** | **Portland State U.** |
|---|---|---|---|---|---|---|
| Systems Analysis | | | Systems Analysis | Systems Dynamics and Systems Thinking | | |
| M&S | | | Modeling and Simulation | | | Business Modeling and Simulation |
| | | | | | | Discrete Multivariate Modeling |
| Integration | | | Systems Integration, Verification, and Validation_1 | | | Hardware and Software Integration_1 |
| Verification | | Verification and Validation Testing_1 | Systems Integration, Verification, and Validation_2 | | | |
| Validation | | Verification and Validation Testing_2 | Systems Integration, Verification, and Validation_3 | | | |
| **SE Mgmt** | | | SE Mgmt | | Program Mgmt | Operations Research in Engineering Mgmt |
| SE Process Environment | Aerospace Roles in Space Systems Architecting, Acquisition, and Engineering | | Engineering Process Mgmt | Organizational Processes | | |

| Source Information | Aerospace Corporation | Cal Tech | INCOSE | MIT | Naval Post Graduate School | Portland State U. |
|---|---|---|---|---|---|---|
| | | | | Managing Changes in Work and Organizations | | |
| SE Planning and Strategy | | SE Mgmt and Planning | | | | |
| | | Managing System Cost and Schedule Estimation_2 | | | | |
| Risk Mgmt | | Managing Risk | | | | |
| Configuration Mgmt | | Using Configuration Mgmt | | | | |
| Cost Analysis | Cost | Managing System Cost and Schedule Estimation_2 | | | Cost Analysis | |
| **DoD Acquisition Related Topics** | | | | | | |
| Source Selection SE Indicators | | | | | | |
| Architecture Frameworks | Architecting | | Req'ts and Architecture Definition_2 | | SE and Architecture_2 | |
| Technology Insertion Mgmt | | | | Managing Technology and Innovation | | |

| **Source Information** | **Aerospace Corporation** | **Cal Tech** | **INCOSE** | **MIT** | **Naval Post Graduate School** | **Portland State U.** |
|---|---|---|---|---|---|---|
| Technical Reviews and Audits | | Conducting Technical Reviews and Audits | | | | |
| **SE Enablers** | | | | | | |
| Software Design and Development | | | | | | Hardware and Software Integration_2 |
| IPPD | | Creating a High Performing Team for SE_2 | | Communicating in Groups and Teams | | |
| **SE Design Considerations** | | | | | | |
| Reliability, Availability, Maintainability | | | Reliability Engineering | | | |
| Test and Evaluation | | Verification and Validation Testing_3 | | | | |
| Producability & Manufacturability | | Producing the system | | | | Manufacturing Systems Simulation |
| Supportability/ Acquisition Logistics | | | | | | Logistics SE |
| Safety and Security | Security systems | | | | | |

| Source Information | Aerospace Corporation | Cal Tech | INCOSE | MIT | Naval Post Graduate School | Portland State U. |
|---|---|---|---|---|---|---|
| **Other** | Computer Systems | | | | | |
| | | Communications Systems | | | | |
| | | Satellite Systems | | | | |

## SE TOPICS: CERTIFICATION PROGRAMS (2)

Sources for this table:

- Reliability Analysis Center (RAC)/American Society of Naval Engineers (ASNE)/Advanced Automating Corporation (AAC)
- Rensselaer Polytechnic Institute (RPI)
- Southern Methodist University (SMU)
- Southern Polytechnic State University
- Stevens Institute of Technology
- University of Alabama, Huntsville (UAH) Professional Development SE Program

| Source Information | RAC/ ASNE/ AAC | RPI | SMU | Southern Polytechnic State U. | Stevens Institute of Technology | U of Huntsville, Alabama |
|---|---|---|---|---|---|---|
| **SE Process** | | | SE Process | Introduction to SE | | Systems Engineering |
| Req'ts Development | | | | | | Req'ts Development |
| Physical Solution/ Design Synthesis | SE: Principles and Implementation: Product Realization | | Systems Design | System Analysis and Systems Design_1 | Systems Architecture and Design | |
| | | | | System Architecture | | |
| Systems Analysis | Maintenance Engineering: Principles and Applications: Analysis_1 | | Systems Analysis Methods | System Analysis and Systems Design_2 | Operational Effectiveness and Life-Cycle Analysis_1 | |

| Source Information | RAC/ ASNE/ AAC | RPI | SMU | Southern Polytechnic State U. | Stevens Institute of Technology | U of Huntsville, Alabama |
|---|---|---|---|---|---|---|
| | SE: Principles and Implementation: Analysis and Evaluation | | Systems Analysis and Optimization | | Systems Analysis, Modification and Simulation | |
| M&S | | | | Modeling and simulation | Simulation and Modeling | |
| Integration | | | Systems Integration and Testing_1 | | | |
| Verification | | | | Verification Program Development and Mgmt_1 | | Systems Validation and Verification_1 |
| Validation | | | | | | Systems Validation and Verification_2 |
| **SE Mgmt** | SE: Principles and Implementation: Technical Mgmt | | | Managing the Technical Effort Associated with Systems Creation | Product Mgmt of Complex Systems | Program and System Mgmt |
| | | | | Verification Program Development and Mgmt_2 | | |

| Source Information | RAC/ ASNE/ AAC | RPI | SMU | Southern Polytechnic State U. | Stevens Institute of Technology | U of Huntsville, Alabama |
|---|---|---|---|---|---|---|
| SE Planning and Strategy | | Competitive Advantage and Operations Strategy | | | Decision and Risk Analysis for Complete Systems | Decision Making |
| Risk Mgmt | | | Integrated Risk Mgmt | | | Risk Mgmt |
| Configuration Mgmt | SE: Principles and Implementation: Product Control | | | Advanced Configuration Mgmt | | |
| | SE: Principles and Implementation: Configuration and Data Mgmt_1 | | | | | |
| Data Mgmt | SE: Principles and Implementation: Configuration and Data Mgmt_2 | | | | | |
| | | | | Engineering Economic Analysis | | |
| Lifecycle Cost Analysis | | | | | Operational Effectiveness and Life-Cycle Analysis_2 | |
| **SE Enablers** | | | | | | |

| Source Information | RAC/ ASNE/ AAC | RPI | SMU | Southern Polytechnic State U. | Stevens Institute of Technology | U of Huntsville, Alabama |
|---|---|---|---|---|---|---|
| Process Models and Standards | SE: Principles and Implementation: SE Standards | | | | | |
| | SE: Principles and Implementation: Models | | | | | |
| Software Design and Development | Specialty Engineering for Product Support: Systems, Applications, and Integration: Software Engineering | | Software SE | Software Product Mgmt | | |
| IPPD | | | | Process Assessment and Improvement | | |
| **SE Design Considerations** | | | | | | |
| Training | Specialty Engineering for Product Support: Systems, Applications, and Integration: Training Systems Development | | | | | |
| Reliability, Availability, Maintainability | Specialty Engineering for Product Support: Systems, Applications, and Integration: Reliability Engineering | | | Reliability Engineering | | |

| Source Information | RAC/ ASNE/ AAC | RPI | SMU | Southern Polytechnic State U. | Stevens Institute of Technology | U of Huntsville, Alabama |
|---|---|---|---|---|---|---|
| | Specialty Engineering for Product Support: Systems, Applications, and Integration: Maintainability Engineering | | | | | |
| | Maintenance Engineering: Principles and Applications: Maintenance Predictions | | | | | |
| | Maintenance Engineering: Principles and Applications: Maintenance Design Methods | | | | | |
| | Maintenance Engineering: Principles and Applications: Operational SE Principles and Applications | | | | | |
| | Maintenance Engineering: Principles and Applications: Analysis_2 | | | | | |

| Source Information | RAC/ ASNE/ AAC | RPI | SMU | Southern Polytechnic State U. | Stevens Institute of Technology | U of Huntsville, Alabama |
|---|---|---|---|---|---|---|
| Test and Evaluation | Specialty Engineering for Product Support: Systems, Applications, and Integration: Testability Engineering | | Systems Integration and Testing_2 | | | |
| | Maintenance Engineering: Principles and Applications: Testing and demonstration | | | | | |
| Producability & Manufacturability | Specialty Engineering for Product Support: Systems, Applications, and Integration: Manufacturing Engineering | Analysis of Manufacturing Processes | | | Design for Systems Reliability, Maintainability, and Supportability | |
| | | Manufacturing Systems Integration | | | | |
| | | Manufacturing Systems Mgmt | | | | |
| Supportability/ Acquisition Logistics | Specialty Engineering for Product Support: Systems, Applications, and Integration: Supportability Analysis | | Logistics SE | | System Supportability and Logistics | |

| Source Information | RAC/ ASNE/ AAC | RPI | SMU | Southern Polytechnic State U. | Stevens Institute of Technology | U of Huntsville, Alabama |
|---|---|---|---|---|---|---|
| | SE: Principles and Implementation: Product Support | | | | | |
| Human Systems Integration | Specialty Engineering for Product Support: Systems, Applications, and Integration: Human Factors Engineering | | | | | |
| **Other** | Specialty Engineering for Product Support: Systems, Applications, and Integration: Information Technology | | | | | |

## SE TOPICS: CERTIFICATION PROGRAMS (3)

Sources for this table:

- University of Arizona
- University of California (UC), Riverside
- University of California (UC), San Diego
- University of Minnesota
- University of Mississippi--Rolla/ University of Southern California (USC)
- University of Southern California (USC)
- Wichita State University



| Source Information | U. of Arizona | UC, Riverside | UC, San Diego | U. of Minnesota | U. of Mississippi--Rolla/ USC | USC | Wichita State U. |
|---|---|---|---|---|---|---|---|
| **SE Process** | SE Process | | | Principles of SE | | SE Theory and Practice | |
| | | | | SE Practices I and II | | Advanced Topics in SE | |
| Req'ts Development | | System Req'ts Development and Analysis | Systems Req'ts Analysis | | | | |
| | | | Systems Software Req'ts Engineering_1 | | | | |

| Source Information | U. of Arizona | UC, Riverside | UC, San Diego | U. of Minnesota | U. of Mississippi--Rolla/ USC | USC | Wichita State U. |
|---|---|---|---|---|---|---|---|
| | | | Systems Req'ts Analytical Techniques and Tools | | | | |
| Functional Analysis and Allocation | | System Concept Development and Selection_1 | Concept Development_1 | | | | |
| Physical Solution/ Design Synthesis | Model-Based Systems Design | System Concept Development and Selection_2 | Concept Development_2 | | Systems Architecting | Systems Architecting | |
| | | System Design and Integration_1 | | | | | |
| Systems Analysis | Simulation, Modeling and Analysis_1 | | | | Engineering Analysis | | Statistical Methods for Engineers |
| | Engineering statistics | | | | | | SE and Analysis |
| | Optimization Methods | | | | | | |
| | Linear Systems Theory | | | | | | |

| Source Information | U. of Arizona | UC, Riverside | UC, San Diego | U. of Minnesota | U. of Mississippi--Rolla/ USC | USC | Wichita State U. |
|---|---|---|---|---|---|---|---|
| M&S | Simulation, Modeling and Analysis_2 | | SE Solutions Using Adaptive Rule-Based Simulation | | Modeling and Simulation | | |
| Integration | | System Design and Integration_2 | Systems Hardware and Software Integration_1 | | | | |
| Verification | | Systems Verification | Systems Validation and Verification_1 | | | | |
| Validation | | | Systems Validation and Verification_2 | | | | |
| **SE Mgmt** | | SE Mgmt | SE Mgmt | SE Mgmt | Mgmt | Engineering Project Mgmt | Engineering Mgmt |
| | | | Program Mgmt Essentials | | | | Analysis of Decision Processes |
| SE Process Environment | | | Program Manager Boot Camp | | | Mgmt of Engineering Teams | |
| Cost Analysis | | | | | | Engineering Economy | |

| Source Information | U. of Arizona | UC, Riverside | UC, San Diego | U. of Minnesota | U. of Mississippi--Rolla/ USC | USC | Wichita State U. |
|---|---|---|---|---|---|---|---|
| **SE Enablers** | | | | | | | |
| Process Models and Standards | SE Models and Methods | | | | | | |
| Software Design and Development | | | Systems Hardware and Software Integration_2 | | | | |
| | | | SE Software Overview | | | | |
| | | | Systems Software Req'ts Engineering_2 | | | | |
| **SE Design Considerations** | | | | | | | |
| **Other** | | | Communications Skills for Technical Professionals | | | | |
| | | | Oral Communications Skills for Technical Professionals | | | | |

# Appendix G
# IDENTIFIED SYSTEMS ENGINEERING BEST PRACTICES OR DEFICIENCIES

# IDENTIFIED SYSTEMS ENGINEERING BEST PRACTICES OR DEFICIENCIES

| **Source** | **Best Practice or Deficiency** | **Recommendations** |
|---|---|---|
| **GAO Reports** | | |
| *Strong Management, Processes, and Metrics Needed to Improve Software Acquisition*, Pending Release | Working in a manageable evolutionary environment | To assure DoD appropriately sets and manages requirements, acquirers should obtain signed agreements with the contractor to confirm software requirements based on knowledge obtained through the completion of systems engineering requirements analysis and require cost/benefit analysis for proposed major requirements changes |
| | Following a disciplined development process | To ensure DoD acquisitions are managed to a disciplined process, acquirers should develop a list of software knowledge deliverable based on the completion of systems engineering that contractors are required to provide at the end of software phases: requirements, design, coding, and testing. |
| | Collecting and analyzing meaningful metrics | To ensure DoD has the knowledge it needs to oversee intensive acquisitions, acquirers should require software contractors to collect and report metrics related to cost, schedule, size, requirements, tests, defects, and quality to program offices on a monthly basis and before program milestones |
| | | Acquirers should ensure that contractors have an earned value management system that reports cost and schedule information at a level of work that provides information specific to software development. |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| *Defense Acquisition: Employing Best Practices Can Shape Better Weapons Decisions,* April 2000 | A knowledge-based approach, based on commercial best practices, should shape DoD acquisition, at three knowledge points:<br>• When technology meets requirements<br>• When the design meets performance standards<br>• When the product can be produced within cost, schedule, and quality targets | In initial stages of product development:<br>• Instill flexibility in both resources provided and the product's performance requirements to allow for the uncertainties of technical progress<br>• Instill high standards for technical maturity |
| *Defense Acquisition: Employing Best Practices Can Shape Better Weapons Decisions,* April 2000, cont. | | Undertake product launch when technology matures enough to meet requirements, as measured by technology readiness levels (TRLs) |
| | | Develop estimates of cost and schedule and finalize requirements only when 90% of the engineering drawings have been finalized |
| | | Initiate full rate production only when it is proved that the product can meet cost, schedule, and quality targets |
| *Better Matching of Needs and Resources Will Lead to Better Weapons Systems Outcomes*, March 2001 | Customer's needs and developer's resources need to be matched early in the process by:<br>• Using systems engineering at the beginning of the process, preferable before it | Do systems engineering early |
| | | Systems engineering contracts should be made with developers before the systems development and demonstration phase |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| | begins<br>• Customer and developer being flexible about making trade-offs and lowering expectations (e.g., deferring additional capabilities to the next generation of a product if including them in the present generation would substantially increase costs or would involve using unproven, immature technology<br>• Customer and developer having equal roles in the process, sharing responsibility for setting requirements | Pressure to set unrealistic requirements should be reduced via top-level involvement |
| *A Constructive Test Approach is Key to Better Weapon Systems Outcomes*, July 2000 | Best practice in testing and evaluation are to test early and use those tests to validate knowledge--use tests to learn from rather than as a scorecard for funding | Program mangers and testers should cooperate in defining and scheduling tests around product maturity levels |
| | | Specific maturity levels should be attained before major program approval |
| *Software and Systems Process Improvement Programs Vary in Use of Best Practices*, March 2001 | Lack of SPI implementation in DoD components | Implement software process improvement (SPI) programs where none exist |
| | No DoD knowledge-sharing activities of best-practice examples of successful SPI programs despite the fact that components with SPI programs reported higher productivity, higher product quality, and higher ROI | Issue IDEAL-based guidance on SPI (IDEAL is SEI's model of Initiating, Diagnosing, Establishing, Acting, and Leveraging) |
| | DoD has not actively promoted and leveraged SPI programs due to resource constraints, doubts about SPI costs and benefits, and other priorities | Perform an annual SPI-compliance assessment and develop DoD-wide activities to disseminate knowledge and best practices on SPI |
| *DoD Teaming Practices Not Achieving Potential Results,* April 2001 | IPTs are more efficient way in which to develop a product or system | Give PMs more responsibility for the product (weapons system program) and more decision-making authority |

| **Source** | **Best Practice or Deficiency** | **Recommendations** |
|---|---|---|
| | Most effective IPTs have members:<br>• Who represent a cross-section of the expertise needed to develop a product<br>• Are collocated<br>• Are selected by the team leader | Designate as IPTs only those teams that will have the day-to-day responsibility for developing and delivering a product and the expertise to do so |
| | Team members, along with the leader, have<br>• Responsibility for delivering the product<br>• Authority to make decisions<br>• The required expertise | Establish a culture supportive of IPTs through a system of professional education for program managers and IPT leaders |
| *Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, July 2002 | Capture design and manufacturing knowledge prior to two key decision points:<br>• When the product design is determined to be capable of meeting product requirements and is stable<br>• When a reliable product can be produced repeatedly and at an affordable cost | Design is stable:<br>• Limit the design challenge<br>• Demonstrate, through prototyping or other means, that product works<br>• Complete design review of system and subsystems<br>• Obtain stakeholder concurrence that the design is complete and producible |
| | Keep the design challenge manageable by adopting an evolutionary approach that minimizes technology changes being made at any one time | Product can be produced:<br>• Identify key system characteristics and critical manufacturing processes<br>• Determine that processed are in control and are stable<br>• Analyze potential failure modes and their effects on performance |
| | | Separate technology from product development |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| *Better Acquisition Outcomes are Possible if DoD Can Apply Lessons from F/A-22 Program*, April 11, 2003 | Evolutionary product development | Knowledge point 1 (should occur before product launch):<br>• Separate technology from product development<br>• Have clear measures and high standards for assessing technology maturity— technology readiness levels<br>• Use a disciplined systems engineering process for translating and balancing customer's desires with product developer's technology, design, and production limitations; in other words, bring the right knowledge to the table when laying down a program's foundation<br>• Identify the mismatches between desired product features and the product developer's knowledge and either (1) delay the start of the new product development until knowledge deficit can be made up or (2) reduce product features to lessen their dependency on areas where knowledge is insufficient (evolutionary acquisition). The main opportunities for trading of design features to save time and money occur here, before a program is started<br>• When do you know you have achieved this knowledge points? When technologies needed to meet essential product requirements have been demonstrated to work in their intended environment and the producer has completed a preliminary design of the product |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| *Better Acquisition Outcomes are Possible if DoD Can Apply Lessons from F/A-22 Program*, April 11, 2003, cont. | Knowledge-based product development process:<br>• Match between customer needs and available resources<br>• Demonstrate ability of product design to meet requirements and is stable<br>• Prove that product can be manufactured given cost, time and quality constraints | Knowledge point 2 (should occur midway between system integration and demonstration:<br>• Hold a major decision review between system integration and system demonstration that determines that the product design is stable and includes specific criteria to move into the system demonstration phase<br>• Use integrated engineering prototypes to demonstrate design stability and prove with testing that the design meets the customer's requirements. It is important that this happen before initial manufacturing begins— a point when investments are increased to produce an item<br>• Identify critical manufacturing processes and establish a plan to bring these under statistical control by the start of production; also establish reliability goals and growth plan to achieve these by production. This facilitates the achievement of process control and reliability goals at the completion of knowledge point 3<br>• When do you know you have achieved this knowledge point? When 90 percent of engineering drawings are releasable to manufacturing organizations. Drawings are the language used by engineers to communicate to the manufacturers the details of the new product— what it looks like, how its components interface, how to build it and the critical materials and processes needed to fabricate it. This makes drawings a key measure of whether the design is stable or not |

| Source | Best Practice or Deficiency | Recommendations |
| --- | --- | --- |
| *Better Acquisition Outcomes are Possible if DoD Can Apply Lessons from F/A-22 Program*, April 11, 2003, cont. | | Knowledge point 3 (should occur before production):<br>• Demonstrate that all critical manufacturing processes are under statistical control and consistently producing items within the quality standards and tolerances for the overall product before production begins. This is important, since variation in one process can reverberate to others and result in defective parts that need to be repaired or reworked<br>• Demonstrate product reliability before the start of production. This requires testing to identify the problems, design corrections, and retest the new design. Commercial firms consider reliability important and its achievement a measure of design maturity<br>• When do you know you have achieved this knowledge point? When all key manufacturing processes have come under statistical control and product reliability has been demonstrated |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| *Better Acquisition Outcomes are Possible if DoD Can Apply Lessons from F/A-22 Program*, April 11, 2003, cont. | | Cultural changes:<br>• Top level needs to take control of investment dollars and say “No” to programs as necessary<br>• Keep key personnel in place long enough to affect decisions and accountability<br>• Provide programs with the necessary skilled people to craft acquisition approaches and over see a contractor’s execution of the program<br>• Realign funding between S&T and acquisition organizations to separate technology from product development<br>• Bring discipline to the requirements process by insisting on a match between requirements and resources<br>• Require readiness and operating cost as KPPs before beginning acquisition<br>• Design and implement test programs to provide the knowledge necessary when needed |
| **DSB Reports** | | |
| *Report of the Defense Science Board Task Force on Defense Software*, November 2000 | | Stress Past Performance and Process Maturity |
| | | Initiate Independent Expert Reviews (IERs) |
| | | Improve Software Skills of Acquisition and Program Management |
| | | Collect, Disseminate, and Employ Best Practices |
| | | Restructure Contract Incentives |
| | | Strengthen and Stabilize the Technology Base |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution*** | | |
| | Requirements Management | |
| | Incomplete definition of requirements | Enforce review of the operational requirements document at Milestone B and do not proceed past the MB if the operational requirements definitions are incomplete, not approved, or not signed by the appropriate approving authorities. Require a complete and signed ConOps document at MB. Require the program to address how the documented operational requirements meet the Operational Views and System Views that include the system. |
| | | Establish a process to assure the proposal solicitation System Requirements Document (RD) is complete and accurate. For major programs, establish an independent review process to assure the completeness and accuracy of the SRD. Require the program to address how the SRD requirements will meet the Operation Views and System Views requirements. |
| | | Reinforce the requirement that the IMP must have well-defined accomplishments with entrance and exit criteria for program milestones and events. The Systems Requirement Review (SRR) must be a key event in the IMP with exit criteria that assure the system specification is complete, including a complete set of verification requirements. The SRR must be the gate which is opened to proceed into design with a complete set of requirements defined or held closed until the system level requirements are defined. |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | Requirements creep | The system program director/manager writes a program directive instructing all program stakeholders to refrain from verbally directing changes to the contractor. All program stakeholders should be instructed not to verbally direct the contractor to implement changes. The contractor should be directed to not accept and act on verbally directed/requested changes. |
| | | Establish written guidance on the role of government personnel when participating in Contractor's IPTs. Include a list of "Do's and Don'ts." |
| | | Require agreement with stakeholders that requirements growth will be properly managed buy changing program baselines. Educate stakeholders on impact of creeping requirements; how it is counter to rapid fielding of operational capability. |
| | | Establish program plans to accommodate requirements changes that exceed the program baseline by deferring them to future upgrades, modifications, or increments. Alternatively, establish formal change to the baseline program with adjustment of the program schedule and costs. |
| | | Establish a process to formally solicit and process all suggested requirements changes. This process should include the leadership of the acquisition organization to assure the requirements changes are reviewed and managed in accordance with the acquisition/contracting rules of engagement. |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | Requirements creep, cont. | Contractually rebaseline the program in terms of performance, cost, and schedule when requirements changes place the newly defined program at risk I the executing within the original performance, cost, and schedule baselines. |
| | | Address requirements identified subsequent to the SRR in future upgrades. Place strict limits on minor requirements changes that are incorporated into the baseline without adjusting the program baseline. |
| | Requirements volatility | Implement program metrics to measure and track the extent of requirements changes in terms of number of requirements “shall statements” changed from contract award forward through the development cycle. This should be tracked for each baseline specification. This would constitute a program metric that is reported and reviewed periodically. If requirements changes continue to grow significantly as the system design development progresses, program officials should expect the scope of work required to complete the program to grow beyond the program cost and schedule baseline. |
| | | Readjust the program schedule and cost baselines if the level of requirements changes becomes excessive to accommodate the increased work generated by high level of change activity. |
| | | It may not be prudent to rebaseline the program to accommodate the rate of requirements changes, especially if they are externally driven. In this case, consideration should be given to accommodating the changes in follow on efforts (contract changes to handle new requirements in later increments, upgrades and modifications). |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | Lack of a specification tree | Establish a requirement in proposal solicitations for delivery of a preliminary specification tree and description of the systems engineering processes that will be used to maintain the specifications and specification tree in the proposal, e.g., in the section L instructions to the offeror. Proposers must include a preliminary specification tree with the proposal and their proposed systems engineering processes must include requirements to maintain and update the specification tree over the life of the development program. This includes maintenance of specifications that are not under government control but are necessary to maintain the integrity of the development process. |
| | Incomplete/weak verification requirements | The concept of writing a verification requirement for each performance requirement “shall statement” must be incorporated into the systems engineering process and requirements definition/specification process including software engineering. This should take the form of a narrative section four in the specification. Examples should be developed that would illustrate how to write verification requirements. Complete definition of verification requirements should be an integral part of writing the specifications and be part of the exit criteria for the formal specification review, e.g., SRR and software specification review. |
| | | This one-to-one performance-to-verification narrative requirements needs to be emphasized in systems engineering training programs. An example of how to white these in the JACG series of specification guides. |

| Source | Best Practice or Deficiency | Recommendations |
| --- | --- | --- |
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | Late requirements forced into software | Apply the systems engineering requirements analysis process to all requirements changes/additions throughout the development cycle. All changes/additions should be formally managed through the change control board process. Changes would either be incorporated through an individual change request or a "bucket" ECP (if contract change), with adjustment in both cost and schedule, or be allocated to a planned subsequent contract development increment. The decision on how to implement the change must consider the criticality and magnitude or the change/additional requirement. Changes that do not require a contract change should also go through a similar contractor controlled change process. |
| | Interface requirements and Interface management | Reinforce the importance of specifying, allocating, and controlling interface requirements including interfaces among the members of a SoS/FoS. In particular, programs need to include verification of interface requirements in development and test plans. |
| | Failure to implement and maintain requirements traceability tools | Programs anticipating a large requirements set should institute a formal requirements traceability process that begins with the ORD and evolves to include the total system. |
| | | Require contractors to implement requirements tracking tools and flow down these tools to the subcontractor base to assure completeness. When appropriate, use commercially available software tools to implement the requirements management and tracking process. |

| Source | Best Practice or Deficiency | Recommendations |
| --- | --- | --- |
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | | Require the government (operational user and program office) to implement a disciplined requirements management process from the ORD through the product requirements documents, e.g., ORD to RFP performance requirements document to contract specifications to product specifications, etc. |
| | Systems Engineering Process | |
| | SE process not defined on program | Programs should have a robust systems engineering process that is comprehensively defined in a systems engineering program plan. The standard corporate systems engineering process can be applied directly to a straightforward, simple program, or can be tailored for a more complex/large/multi-contractor team program. The proposal solicitation should require. In section L, s systems engineering process description tailored to the program as part of the proposal. This could be in a contractor format, but must address the systems engineering processes as they will be applied to the program. |
| | SE processes defined but not applied | Map the systems engineering processes defined in the program systems engineering plan, to the IMP, including entrance and exit criteria for the program reviews and events. Specifically identify systems engineering task completions as entrance and exit criteria. Examine planned programmed resources to ascertain if adequate resources are budgeted to execute the proposed systems engineering processes. |
| | | Task and incentivize contractors to follow the program's systems engineering plan through the use of award fee. Include metrics that measure program progress, processes implemented, and are tied to products. |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | | Train the program participants in the execution of systems engineering processes, including value of the processes and importance to applying the systems engineering processes. |
| | Lack of flow down of SE process requirements to development subcontractors | Contractors should be required to address how the systems engineering process will be applied across all systems and subsystems development on the program in their proposal, including those subsystems that are subcontracted. This systems engineering process must be described in the proposal, and after contract award published in a program document available to all program participants and stakeholders. Prime contractors should be required to flow down a requirements for a defined written systems engineering process to their development subcontractors. |
| | Lack of robust SE applied to top level system design | Require completion of the top level system design and requirements allocation to subsystems prior to initiation of the subsystem design activity. Employ IMP criteria for the SRR and system level design review events to assure completeness. |
| | | Include basic systems engineering on programs that have substantial requirements definition and top level efforts prior to milestone B, e.g., during technology development. Complete the system level requirements and design per defined criteria prior to MB if appropriate. |
| | Lack of timely system integration and test (I&T) planning | Require systems level integration and test planning early in the program. Evaluate the IMP and IMS for test and evaluation planning realism during the source selection. |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | | Require all test requirements be identified in specifications by the SRR and plans be in place to satisfy the requirements by the PDR; include test and evaluation as a topic in program and design reviews. Assure there is only one test requirements baseline for the program that all stakeholders use. |
| | | Require a full comprehensive integration and test plan as entrance criteria for CDR. |
| | Inadequate planning for obsolescence and sustainment | Establish requirements early in the program to accomplish technology refresh to preclude obsolescence early in the program and include the topic throughout the development process. |
| | | Perform the expectancy analyses for parts susceptible to early obsolescence as part of the systems engineering processes very early in the development cycle and include design considerations that facilitate technology refresh. |
| | | Include sustainment as a topic throughout the design process; include sustainment specialists in program planning activities. |
| | Design incorporated into performance specifications | Employ templates for performance specifications; include examples such as those contained in the JACG's series of specification guides. |
| | | Enforce the Performance Based Business Environment (PBBE) initiative on multipart product documentation that separates the performance language documentation from the product description language documentation. |
| | Engineering Management | |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | Inadequate schedules and budget to accomplish development effort | Senior government personnel should challenge unrealistic schedules at Milestone Reviews, acquisition strategy panels (ASPs) and RFP reviews. For software intensive programs, the results of software estimating models runs should be presented to these reviews to substantiate the viability of the planned schedule and budgeted resources. In addition, planned schedules should consider actual schedules from past completed programs. |
| | | Sound rationale for proposed schedules and cost tied to performance requirements should be demanded at Milestone Decision Authority (MDA) reviews. |
| | | A means to get realistic industry feedback based on accurate assessment of the requirements development effort, rather than just acceptance of risky conditions stated in draft proposal solicitations, needs to be established. Industry foes challenge performance requirements on occasion, but often does not challenge immature technology expectations, budget/cost baselines, nor schedule expectations for fear of being non responsive or not competitive. A true non-attribution exchange needs to occur. |
| | Assumed reuse not confirmed | Base planned reuse and COTS on factual data. Include systems engineering analyses of the reuse candidates to determine that the candidates exist in acceptable usable form, that they need meet the new system requirements, and they are well documented and designed for reuse. |
| | | Pan ad accomplish early demonstrations, prior to PDR, of the reuse candidates on system simulations, i.e., verify the reusability early. Include these demonstrations in the risk management program as risk mitigation activities. |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | | Require proposed reuse to be fully supported in the proposals and consider risks in the evaluation. The proposal solicitation should include a reuse checklist to address the soundness of the proposed reuse candidates and approach, confirm reuse compliance with requirements, quantify the attendant risk, and require development of risk mitigation plans. |
| | Lack of active engineering management of development subcontractor | RFPs should require proposers to describe the systems engineering processes that will be used to technically manage subcontractors development key subsystems. |
| | | Contracts with the primes should be structured to require technical engineering management visibility and status reporting (metrics) of major development activities at the subcontractor level and included in the prime contractor's reporting forward. |
| | Integrated master plan/Integrated master schedule (IMSP/IMS) not adequately addressed and/or not followed on the program | Require the offeror to propose a system level IMP and IMS. Evaluate these products during sources selection and make sure the key system engineering and engineering d3evelopmetn events have appropriate entry level criteria and the adequacy of the planned systems engineering task durations. |
| | | Keep the system IMP/IMS at the appropriate level. Focus on key gating events and important criteria. Establish subsystem IMP/IMS as appropriate and flow the requirement to subcontractors and vendors as appropriate. |
| | | Incentivize the program to mange/execute the program following the IMP/IMS. |
| | | Enforce the criteria included in the IMP; don't just gloss over event and accomplishment exit criteria. |

| Source | Best Practice or Deficiency | Recommendations |
| --- | --- | --- |
| **Dayton Aerospace *Quick Study Report on the Health of SE Process Execution, cont.*** | | When actions are needed to close criteria partially met, establish near term follow-up plans to assure the actions are completed and the IMP criteria are fully met. |
| | | Most importantly do not close the event, e.g., CDR, until all established exit criteria are met. |
| | No single technical focal point | Require creation of a single technical authority that is responsible for the overall technical effort and empowered to resolve technical issues. This position should be established both in the government program office and the contractor program office. This technical authority should report to the Program Director. |
| **Tri-Service Assessment Initiative** | | |
| | No defined processes in place—Rudimentary processes are missing | |
| | Program team processes established, but not following accepted processes--Process adherence shortfalls in requirements definition/management, risk management, testing, and systems engineering management | Process capability should be evaluated at RFP and major milestone reviews |
| | Poorly executed processes | |
| | Constrained processes | |
| | Process capability shortfalls—program team is following accepted processes, but the processes used are ineffective for the specific program situation encountered | Program teams must be educated in the difference between achieving process adherence (following some process) and implementing process capability (the true effectiveness of that process) |
| | Outmoded processes—process model, standard or practice no longer supported or is inappropriate for the specific program situation | Program teams need to evaluate the full spectrum of technical and managerial process requirements and then tailor their organizationally-based adherence models to meet specific program needs |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Tri-Service Assessment Initiative, cont.** | Pro forma processes—process adequately defined but performed in a "check the box" manner | Individual program team members need to ensure collectively that their technical and managerial processes meet the needs of the program team as a whole. Too often, program team members simply adhere to their process model, standard, or individual best practice, without understanding how their process may clash with another team member's processes, or whether it is adequate for the specific program in question. |
| | Non-integrated team processes—full spectrum of program team's organizational processes are not rigorously evaluated and then tailored to meet the specific characteristics or requirements of the program | DoD must foster innovative processes and practices that are capable of handling the emerging complexity of system acquisitions, developments, and deployments |
| | No accepted processes defined--Emerging processes/missing innovative processes—largely revised or new process is required but program team has failed to define it in sufficient detail so that the process adequately addresses the identified risk or problem | |
| **Space Broad Area Review** | | |
| | System design and process engineering deficiencies played a prominent role in failures and near misses -- program management | Failures and major anomalies reflect the need for contractor program management to provide more disciplined systems engineering in design and processes |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **Space Broad Area Review, cont.** | Formal risk management policies, practices and procedures have been degraded over the past decade—No formal technical risk management process | Institutionalize a formal launch risk management program<br>– Develop and manage a risk management plan for all fly-out systems<br>– Emphasize identifying and mitigating risks<br>– Formalize systems engineering and quality policies, practices and procedures<br>– Re-institute a comprehensive post-flight analysis program |
| | Engineering process and workmanship are both prominent in mishaps since 1985 -- historically consistent themes<br>– Lack of disciplined system engineering in design and processing of launch vehicles<br>– Lack of communication of critical data<br>– Inadequately defined processes<br>– Inadequate review process -- particularly in design and design change | Air Force formulate a formal EELV launch risk management program<br>– Develop and manage a risk management plan for EELV systems<br>– Formalize systems engineering and quality policies, practices and procedures<br>– Develop and implement an improved mission assurance process based on the best attributes of SMC, NASA and NRO mission assurance practices |
| **NDIA Top Five SE Issues** | | |
| | Lack of awareness of the importance, value, timing, accountability, and organizational structure of SE on programs | Increase awareness of SE importance within acquisition formulation and decision processes early and consistently over major milestones, and recognize SE authority and responsibility in the ACAT IC/D process present during the acquisition formulation and decision processes, with similar efforts at lower program levels. |
| | General awareness of cost benefit and return on investment performance of SE possesses is unknown It would be most helpful to have a “lessons learned” repository | SE is NOT an option. It is an essential ingredient on all programs and must have adequate funding. |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **NDIA Top Five SE Issues, cont.** | There is a lack of commitment to SE across the life cycle of programs | PMs are accountable and responsible for SE implementation across entire life cycle |
| | There is a lack of understanding on the application of SE principles, content and areas of application to program success, including areas such as risk management, security, COTS integration, architectures, identification of cost drivers, test & evaluation, and supportability/life cycle cost | It would be most helpful to have a “lessons learned” repository |
| | Program managers, both industry and government, do not have adequate recognition that SE touches all aspects of the acquisition process, e.g. from up-front requirements, budgeting, to end of life disposition | |
| | Systems Engineering content, when included in proposal costs as a factor versus bottom-up quoting, exacerbates the problem of funding when costs are being evaluated as it is looked at as “overhead” that becomes a prime candidate for cost cutting | |
| | Adequate, qualified resources are generally not available within Government and industry for allocation on major program | Establish a program and process for incentivizing career systems engineer positions within the Government. |
| | An experienced, trained workforce is in short supply. There is sufficient opportunity for systems engineers in Government but inequities in compensation and incentive versus industry for systems engineers at midcareer (e.g. 10-20 years) encourages migration out of Government service. | Require the SEMP to identify the process and qualification requirements for all key personnel proposed for the contract |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **NDIA Top Five SE Issues, cont.** | We do not consistently allocate adequate, trained resources on programs | Work with major universities to require an introductory course in systems engineering in all undergraduate and graduate level engineering and technical management degree programs. |
| | Program management turnover is an impediment to success | Require that program managers receive systems engineering training so they understand the significance that SE plays in assuring program success |
| | The DAWIA certification process levies only minimal academic requirements and does not produce adequately trained systems engineers because of inadequate systems engineering experience is required as a qualification | Ensure that DAU SE level 2 and 3 courses address, as a minimum, training on the SE tools processes and documents as defined in SAF AQ memo dated January 06, 2003, "Incentivizing Contractors for Better Systems Engineering". |
| | Opportunities in industry to gain systems engineering experience are limited by the number of and completeness of systems engineering content on programs | |
| | A limited number of academic and practical sources of systems engineering curricula and a very limited number of graduates are available to either industry or government | |
| | There are inadequate certification methods in both industry and government to insure the quality and competency of systems engineer | |
| | Insufficient SE tools and environments to effectively execute SE on programs | Research and identify SE tools for system architecture design and development, and encourage use thereof. |
| | The SE community lacks a set of comprehensive, common and consistent tools, guidance and standards, and metrics, which leads to stovepipes and inadequate data and data transfer | There is need for development of a system architecture framework for particular system in accordance with FEW [federal enterprise architecture/CBA-component based architecture, the DoD-directed Zachman framework, and C4ISR three-schema architecture] |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **NDIA Top Five SE Issues, cont.** | In terms of the environment definition – there is insufficient understanding of both the individual and System-of-System interdependency of product, process, and people/organization environments. There are insufficient SE tools to properly define the various environments (Modeling and Simulation domain.) | Efforts should identify all of the program-applicable domains (government, primes and major subcontractors) and environments required for a structured hierarchical decomposition of a weapon or IT system |
| | Substantial data inconsistencies exist – there is no common data dictionary, use of metadata (meaning and definition of data), Configuration Management of data, and use of common terminology. There is insufficient Validation/Verification and certification of data, resulting in little data sharing and reuse | |
| | In terms of tools and product environments, there is no overall SE tool system, from a hierarchical standpoint, that incorporates the detail design, life cycle cost, and overall performance, including those needed for SOS and Interoperability. | |
| | There is little or no integration of Systems Engineering Computer Aided Engineering (CAE) tools with software and hardware design tools, and likewise between the tools and models used by government and Industry | |
| | There is no requirement to use a requirements management s/w tool (such as DOORS, RTM, or SLATE) | |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **NDIA Top Five SE Issues, cont.** | Requirements definition, development and management is not applied consistently and effectively | Synchronize directives used by the acquisition and requirements community to ensure a disciplined and consistent requirements definition and development approach. |
| | The Government, for the most part, within the contracting and war fighting/operational communities do not have the Systems Engineering mentality in addressing Mission Needs and requirements and do not follow their requirements process effectively. | The education process, both formal and informal, for Government Program Managers and contractors should be sufficient that they mutually understand the necessity of a comprehensive architectural approach and systems engineering focus in applying the complete and managed requirements process on programs |
| | Acquisition and requirements communities follow different directives | OSD should link requirements definition, development and management into the program life cycle through defined practice and guidance |
| | There is often a lack of understanding by contractors / government of true capabilities and requirements needed by the war-fighter, resulting in incomplete or inaccurate Requirements Definition with respect to implications of stated requirements | Emphasize process maturity related to requirements for both acquisition and development communities by adoption of maturity models such as CMMI (Capability Maturity Model Integration) |
| | There is a serious lack of upfront and continuous requirements development and management, including management of requirements changes | Involve potential contractors in the requirements definition process early in the acquisition cycle |
| | Determining adequate and correct requirements for software intensive systems that satisfy the overall systems objectives is an elusive task | |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **NDIA Top Five SE Issues, cont.** | We do not adequately plan for systems adaptability/reconfigurability to support rapidly changing requirements, both customer and end-user, (i.e., spiral development and evolutionary acquisition) and technology insertion requirements not generally not defined at program outset | |
| | Poor initial program formulation put successful execution at risk. Initial Program Formulation begins prior to at Milestone 0 and culminates with Award of SDD Contract. During this timeframe, many critical decisions are made that have potentially profound impact on the program. These include establishing initial cost and schedule baselines, system requirements, and the management approach. | Emphasize the use of architecture development and systems engineering practice in the initial program formulation phase including the use of realistic estimates for cost and schedule, risk identification, and clearly defining requirements. Even if the program does not include all life cycle phases, consideration of supportability needs to be included from the outset. |
| | Government & Contractor Program Managers are required to meet predefined baseline cost & schedule. Early estimates of program cost and schedule need to be made based upon a true and valid estimate of the work, not the desired price and timeline. This is at odds with the environment under an evolutionary acquisition approach. | Modify the current acquisition approach to encourage more candid communication of program cost, schedule and risk between Government and Industry. |
| | Moreover, if the attempt is made to make programs more palatable by using optimistic scheduling and cost estimating initially, the program's ability to establish and consistently implement effective systems engineering and associated processes is immediately put at risk | Encourage that initial engineering go beyond the superficial, either through pre-acquisition activities and funded studies and analysis so that initial program formulation accurately predicts schedule, cost and risk. |

| Source | Best Practice or Deficiency | Recommendations |
|---|---|---|
| **NDIA Top Five SE Issues, cont.** | When the initial funding profile does not address full lifecycle, later attempts to recognize the true implications of the initial program could result in unfunded surprises and the eventual down sizing of the initial program. | Ensure that unrealistic or incompatible cost, schedule, and performance baselines are clearly identified as a risk, so that the situation can be effectively managed. |
| | The guidelines used for acquisition are sometimes interpreted as discouraging the telling the real story under the guise of ensuring competition or "keeping the program alive". Clearly exposing the requirements, constraints, ramifications and implications of variants, criteria for decision making, budgetary issues, and customer desires would lead to better understanding on the part of the acquisition staff, the PMO, and the bidding contractors and to successful program results. | Emphasize investigation of the implications of initial requirements statements, not only on design but also on supportability. |
| | Program organizational structures, both government and industry, tend to enable IPTs too early in the execution phase, before system level requirements are firm and able to be allocated to the element/subsystem level. Such strong IPTs and weak Systems Engineering Integrated Teams (SEITs) or Overarching IPTs (OIPTs) foster integration problems at the system level. | Encourage early and strong government/industry SEIT or OIPT activity prior to formation and chartering of specific IPTs |
| | There is inadequate emphasis on architecturally scalable designs and development strategies that can readily accommodate normal requirements growth, especially those programs involving spiral development and evolutionary acquisition. | Emphasize process maturity in contractor communities, applicable to all phases of a program, by adoption of maturity models such as CMMI (Capability Maturity Model Integration) |

# Appendix H
# DAU's SYSTEMS ENGINEERING DEPARTMENT REVAMPING SYS-301 COURSE

**DAU'S SYSTEMS ENGINEERING DEPARTMENT REVAMPING SYS-301 COURSE**



# DAU's Systems Engineering Department Revamping SYS-301 Course

## Systems Engineering Competencies at Core of Recent Changes

DR. MARTIN FALK

Systems engineering is an interdisciplinary engineering management process that evolves and verifies an integrated, life cycle balanced set of system solutions that satisfies customer needs. It clearly is at the heart of the systems acquisition process, and the DoD relies heavily on systems engineers to provide technical support to program managers. In fact, the Systems Planning, Research, Development and Engineering (SPRDE) career field has more members than any of the other 12 Department of Defense (DoD) acquisition career fields. One way the DoD ensures that its systems engineers possess the needed competencies to perform their jobs is through a certification process that includes specific training requirements.


### The Original SYS-301 Course

In 1991 Congress passed the Defense Acquisition Workforce Improvement Act (DAWIA). In response, DoD created the Acquisition Workforce Certification Program. This program established education, training, and experience criteria for each of the 13 acquisition career fields. The SPRDE career field has as one of its criteria for level III certification completion of a two-week course called Systems 301 (SYS-301), Advanced Systems Planning, Research, Development and Engineering (ASPRDEC).

As the first step in developing this course, the Defense Acquisition University (DAU) conducted a number of

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workshops with field activities to get their input on what material should be covered. We received over 400 distinct suggestions, ranging from broad areas such as configuration management to specific skills such as being able to do word processing. These inputs were narrowed down into about 30 topic areas by combining related items. Lesson plans, including learning objectives, were then developed for each topic area. A DoD-level functional board oversaw this process and by 1994 the first class was held.

### Need for Change

In subsequent years, course materials were updated to ensure currency and minor changes were made to most lessons to incorporate suggested improvements, but the learning objectives and course structure remained relatively stable. By the end of 1999, however, it was becoming obvious that the skills and competencies needed by senior technical managers were changing. Issues such as the need for systems interoperability and increasing use of software to perform system functions were becoming vitally important. On top of this, a major change in how the DoD would do systems acquisition was soon to be expressed in the new 5000 series of acquisition regulations.

Recognizing that it was time to make a substantial revision to the SYS-301 course, DAU's Systems Engineering Department began a process of interviewing 20 program managers and technical managers from the three Services, other agencies, and industry. Managers were asked what they felt were the skills that senior technical managers needed to be most effective. These skills were then consolidated into 15 skill areas.

Once these skill areas were compared to the SYS-301 course content, we discovered that several subjects covered in the course—such as International Acquisition and Environment, Safety, and Health (ESH)—had not been mentioned in the interviews. Since the goal of this research was to provide direction for a curriculum revision, we decided to modify the original 15 areas to ensure that

FIGURE 1. **Systems Engineer Competencies**

1. Total Systems View
Ability to think beyond engineering and consider all functions and stakeholders in the Systems Engineering process. Ability to understand the entire acquisition process.

2. Teaming
Ability to build, work in, motivate, and lead high-performing multidisciplinary teams.

3. User Focus
Ability to understand the user's perspective and requirements. Ability to conduct requirements analysis and to structure Research and Development work effort to match user needs.

4. Contract Technical Management
Ability to understand contractors' processes and perspectives, to work with contractors and provide informed assessments of their progress, and to understand the source selection process.

5. Configuration Management
Ability to manage and communicate changes to systems in all phases of the life cycle.

6. Post Production Support
Ability to identify improvements to systems for the purpose of Operations and Support (O&S) cost reduction, safety, replacing obsolete parts, reliability, tech insertion, etc. Ability to use Systems Engineering process to implement these changes.

7. Financial Management
Ability to understand the Planning, Programming and Budgeting System (PPBS) system, sources and uses of funds, and how budget issues impact the program.

8. Operational Cost Reduction
Ability to assess design impact on Total Operational Cost and identify means to reduce Total Ownership Cost (TOC). Ability to understand designing for change using techniques such as open systems architectures. Ability to understand Cost As an Independent Variable (CAIV).

9. Risk Management
Ability to plan, assess, handle, and monitor risk.

10. Management of Changing Technology
Awareness of current state-of-the-art, and mechanisms to introduce technology. Ability to accurately assess technology maturity of a system. Ability to understand Information Technology and how to effectively acquire and use it. Ability to understand spectrum management, system security, and Joint Technical Architecture.

11. Earned Value
Ability to understand Earned Value (EV) principles, evaluate EV data, and make recommendations.

12. Software Management
Knowledge of software development principles and techniques. Ability to integrate software considerations into the systems engineering process. Ability to assess development progress and identify risks and pitfalls.

13. Design Impacts on Manufacturing
Understanding of producibility issues and how to manage the design for producilility.

14. Modeling and Simulation
Ability to understand uses of Modeling and Simulation (M&S). Ability to use M&S throughout the life cycle and to assess the contractor's use of M&S. Ability to work in an integrated data environment.

15. Ethics
Ability to understand ethical considerations and adhere to ethical principles.

16. Environment, Safety and Health (ESH)
Ability to understand Environment, Safety and Health (ESH) requirements and how to design systems to effectively meet those requirements.

17. International Acquisition (IA)
Ability to understand International Acquisition (IA) policy and techniques. Ability to utilize offshore technology in system design where it provides a benefit. Ability to understand interoperability requirements.

18. Test Integration
Ability to assist in test planning and design. Ability to respond to issues arising during test.

19. Logistics Integration
Ability to understand designing for supportability. Ability to develop or evaluate design changes in response to supportability issues.

20. Evolutionary Acquisition/Open Systems Architecture
Ability to develop Evolutionary Acquisition (EA) design strategies and ensure system design supports the EA approach. Ability to understand open systems architectures.

21. Assimilation and Communication of Technical Information
Ability to evaluate technical issues, assess program performance, make recommendations, and effectively present these issues to diverse audiences.

22. Adaptability
Ability to respond quickly and effectively to changing conditions or events that impact the program's systems engineering process.

all topics already covered in the course were included.

Figure 1 displays the final list of 22 areas. We termed these "Systems Engineer Competencies." By no means is this a comprehensive list of all competencies required by systems engineers. Domain-specific technical knowledge, organizational knowledge, management skills, and many behavioral competencies are not included. These competencies were beyond the scope of SYS-301, and it was assumed they would be acquired through other means.

The interview process did not prioritize the competencies and used too small a sample to treat it as representing the thoughts of the entire acquisition community. The next step, therefore, was to develop a questionnaire that could be administered to a broad cross-section of senior program managers, engineers, and technical managers.

The first part of the questionnaire asked a number of demographic questions. The second part, displayed in Figure 2, asked respondents to rate each of the 22 competencies as having high, medium, or low importance. In order to distinguish those of highest importance, respondents were asked to rate not more than eight competencies as high.

The questionnaire also asked for an assessment of the degree to which DoD's technical workforce possessed each competency. We did this to allow an analysis showing where there were gaps between: 1) how important a competency is, and 2) the current level of competence. Space was provided for respondents to add any competencies not on the list that they thought were important.

The survey was administered to 137 students while they attended the SYS-301 class, to 96 students in the Advanced Program Management Course (APMC), and to 90 senior technical managers throughout DoD. Respondents were able to fill out the questionnaire online with their input going directly to the Center for Research, Defense Acquisition University. They were then able to analyze and sort responses by Service, years of experience, rank, and several other categories using the "GroupSystems Survey Tool" by GroupSystems.com

## Study Results

Figure 2 shows the overall rankings for the entire population of 323 responses, with competencies listed in descending order of importance. The corresponding assessment of the degree to which people in the SPRDE career field possess these competencies is listed in the right column of Figure 2.

The first four competencies were rated "high" importance by the majority of the respondents. The next nine had at least twice as many "high" ratings as "low" ratings. Only the last three had more "low" than "high" ratings. Of interest is the frequency of "low" ratings for the observed degree of competence. Only five of the 22 competencies received more "high" than "low" ratings. Half had more than twice as many "low" ratings as "high" ratings.

For the most part, the three sample groups had similar rankings for both "importance" and "degree observed." There were, however, some notable exceptions.

- The Advanced Program Management Course students ranked "operational cost reduction" and "financial management" much higher in importance and "test integration" much lower in importance.
- Senior technical managers ranked "ethics" much higher in importance.
- The ASPRDEC students ranked "modeling and simulation" much higher and "adaptability" much lower in importance.
- The ASPRDEC students ranked "assimilation and communication of technical information" and "adaptability" much lower for degree observed.
- Senior managers ranked "user focus" much lower for degree observed.

FIGURE 2. **Questionnaire**

| | Competency | Importance | Observed |
|---|---|---|---|
| 1. | Total Systems View | High | Moderate |
| 2. | User Focus | High | Moderate |
| 3. | Risk Management | High | Moderate |
| 4. | Teaming | High | Moderate |
| 5. | Assimilation & Communication of Technical Information | Moderate–High | Moderate |
| 6. | Software Management | Moderate–High | Moderate–Low |
| 7. | Management of Changing Technology | Moderate–High | Moderate–Low |
| 8. | Test Integration | Moderate–High | Moderate |
| 9. | Operational Cost Reduction | Moderate–High | Moderate–Low |
| 10. | Adaptability | Moderate–High | Moderate–Low |
| 11. | Logistics Integration | Moderate–High | Moderate |
| 12. | Configuration Management | Moderate–High | Moderate |
| 13. | Contract Technical Management | Moderate–High | Moderate |
| 14. | Evolutionary Acquisition/Open Systems Architecture | Moderate | Moderate–Low |
| 15. | Financial Management | Moderate | Moderate–Low |
| 16. | Design Impacts on Manufacturing | Moderate | Moderate–Low |
| 17. | Ethics | Moderate | Moderate–High |
| 18. | Modeling & Simulation | Moderate | Moderate–Low |
| 19. | Post Production Support | Moderate | Low |
| 20. | Earned Value | Moderate–Low | Moderate–Low |
| 21. | Environment, Safety & Health | Moderate–Low | Moderate |
| 22. | International Acquisition | Moderate–Low | Low |

Since the three groups had different perspectives due to the nature of their jobs, some differences were to be expected.

### Analysis

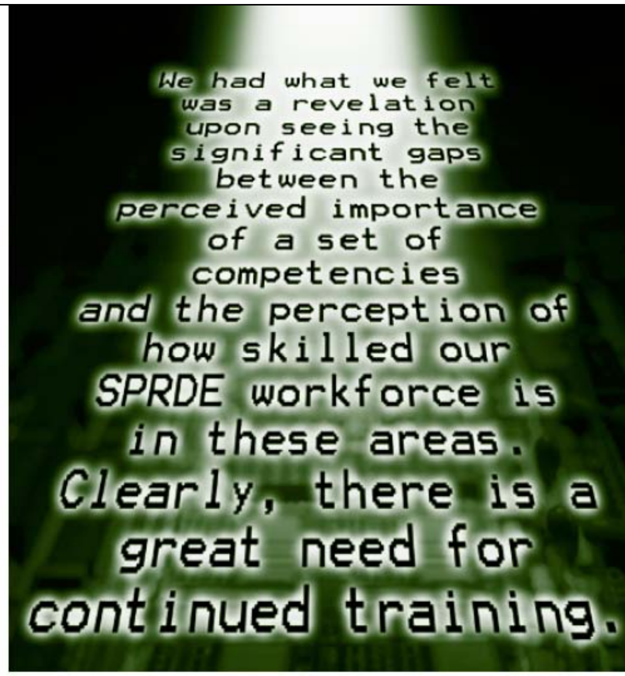
Our next step was to determine what this research suggested as to how we should adjust the SYS-301 course material. Rather than merely focus on the most important competencies, we felt it important to take into account how well the SPRDE population was already doing in each area. The thought here was that areas where we are already doing well may not need extra emphasis, even if they are important. Conversely, areas where we are doing poorly may need extra emphasis, even if they are not the most important.

To help us in this assessment, we did a "gap analysis." We assigned numerical values to high (8), medium (4), and low (1) ratings and then averaged the responses to get numerical values for each competency. The results (Figure 3, next page) show that significant gaps exist in about half of the competencies.

After evaluating this information we drew the following conclusions about how much emphasis each area should receive in SYS-301. This does not imply that any of these areas are unimportant. It just recognizes that time constraints limit what material can be covered in one class. To the extent students need additional training in areas we don't strongly emphasize, other resources are available to provide that training.

STRONGLY EMPHASIZE
Total Systems View (H)
Risk Management (H)
Teaming (H)
User Focus (M)
Assimilation and Communication of Technical Information (M)
Software Management (L)
Management of Changing Technology (M)

EMPHASIZE
Operational Cost Reduction (L)
Adaptability (L)
Evolutionary Acquisition/Open Systems (M)




Logistics Integration (L)
Test Integration (L)

EMPHASIZE SOMEWHAT
Modeling and Simulation (M)
Post Production Support (L)
Design for Manufacturing (M)
Financial Management (L)
Contract Technical Management (M)
Configuration Mmanagement (L)

LITTLE EMPHASIS
Earned Value (L)
Ethics (M)
Environment, Safety and Health (M)
International Acquisition (M)

The next step was to determine how much emphasis each area was already receiving in SYS-301. All faculty members then teaching the class were asked to estimate how many hours were spent in each area. Areas with more than 4 hours were ranked "high," those with between 2 and 4 hours were ranked "medium," and areas with less than 2 hours were ranked "low." These ratings are shown in parentheses in the areas of emphasis covered above.

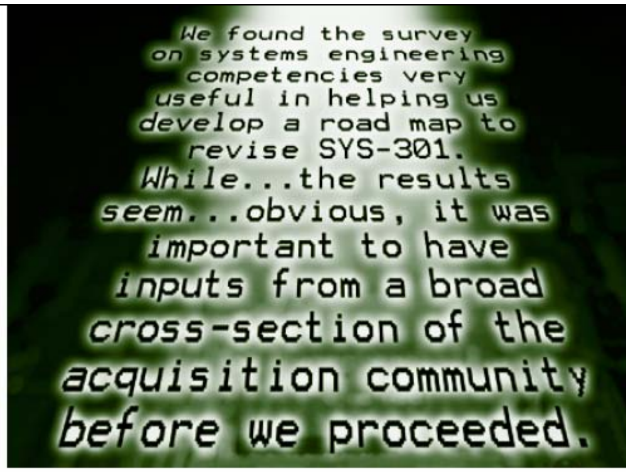
Students in three ASPRDEC classes were also asked their assessments of what was actually being taught. They agreed closely with the instructors except for the area "management of changing technology," which they felt should have much more emphasis. A comparison between what was needed and what was being taught shows agreement in most areas, but it also highlighted several areas where changes were indicated.

**More Emphasis**
Software Management
Operational Cost Reduction
Management of Changing Technology

**Less Emphasis**
International
Environment, Safety and Health
Ethics

### DoD Workforce Report

During this same period, the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics was conducting a study of competencies required by the DoD acquisition work-




force. This study resulted in a report titled "Future Acquisition and Technology Workforce Report." This report listed 435 functional competencies. Of these, 274 were relevant to the SPRDE career field. These were grouped into 33 "environmental trends."

A comparison with our study results indicated very good agreement. For example, two of the environmental trends were "increased emphasis on interoperability" and "increased emphasis on software development." A number of environmental areas addressed the need to reduce operational costs through a variety of means.

### Implementation

With this information in hand, we began to incorporate changes into the course material. A new two-hour lesson titled "Architecture and Interoperability" addressed systems architectures and current policy on interoperability requirements and certification. This knowledge is then used in a case study where students develop a system architecture and look at interface requirements. Six hours of instruction in software acquisition were added. Topics covered include policy, development strategies, the software life cycle, best practices, and software risk management.

In order to make space for this new material, we decided to eliminate the Contracting Issues lesson and shorten the ESH and International Acquisition lessons. While the survey results didn't make a strong case to eliminate the contracting lesson, we felt that most of the students had already received more contracting training than we were providing. We also felt that those students needing more training in this area would be better served by taking a separate contracts course. The ESH and International Acquisition lessons were shortened in response to our survey results.

Some additional material on operational cost reduction was added to existing lessons, but this area requires further work. While the Ethics lesson, which is based on the Challenger incident, remains, we are using it to also address issues of effective decision making in addition to purely ethics issues.

### The Way Ahead

We found the survey on systems engineering competencies very useful in helping us develop a road map to revise SYS-301. While many of the results seem intuitively obvious, it was important to have inputs from a broad cross-section of the acquisition community before we proceeded. We did find some obvious gaps between what was being taught and what our customers felt they needed. We also had what we felt was a revelation upon seeing the significant gaps between the perceived importance of a set of competencies and the perception of how skilled our SPRDE workforce is in these areas. Clearly, there is a great need for continued training.

While we changed SYS-301 significantly, we will continue to make additional changes that will address those study issues that have not yet been implemented. Our changes will also include new material required to keep the course current as the acquisition environment continues to evolve.

SYS-301 is not the only systems engineering course to have undergone change. In June of 2001 DAU introduced a revised Systems 201 (SYS-201) course—Intermediate Systems Planning, Research Development & Engineering—that converted what was formerly a two-week, in-residence course into a hybrid course with a distance learning portion followed by one week in class. One of the options we are considering for SYS-301 is to convert it to a hybrid course in the future.

**Editor's Note:** For questions/comments, contact Falk at **martin.falk@dau.mil**.

FIGURE 3.
**Gap Analysis**

# Appendix I
# LMI WORKFORCE REPORT SPRDE/SE FUNCTIONAL COMPETENCIES

**LMI WORKFORCE REPORT SPRDE/SE FUNCTIONAL COMPETENCIES**

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| RDT&E Consolidation (Centers of Excellence) | Perform Business Case Analysis (BCA) (mission, capabilities, cost, trends, future, cross-Service opportunities to include technical capabilities). | Analyze and evaluate different categories of data such as cost and technical capabilities. Analyze business data to determine its adequacy and impact on consolidation of RDT&E organization | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers |
| | | Use tradeoff analyses to asses most appropriate consolidation recommendations | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | | Know and understand service capabilities/core competencies | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | | Know critical elements contained in a Business Case Analysis (BCA) in order to justify sound business outcomes. | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | Develop streamlining and implementation planning for consolidation | Use Business Case Analysis (BCA) to assess effectiveness of the economies of budgeting inherent government functions or centers of excellence and service contracting in the business sector. | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | | Know and understand joint and service strategic planning and requirements process; assess impact of consolidation options. | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand methods for building innovation operations that consistently improve over time. | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | | Know and understand the Planning, Programming and Budgeting System (PPBS) and DoD monetary policies and procedures; Assess fiscal impacts and synthesize consolidation options | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | | Know effective streamlining and implementation planning documentation | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | Operate in a Multi-Service Environment | Know and understand RDT&E process; evaluate consolidation/process change options; synthesize win-win solutions | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | | Know and understand virtual RDT&E resources/network applications; ability to assess applicability and determine best consolidation applications | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | | Know and understand how to function in a Multi-Service environment. | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |
| | | Understand operation systems that effectively connect operations with customers, distribution channels, and suppliers | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Operate in Integrated Product and Process Development (IPPD) environment in developing policy, provide guidance within DoD/Industry groups and support development of performance based work statements and definition of performance events. | Critical for personnel in proposed consolidation decisions. Training should be specifically focused to the Labs and Centers |
| RDT&E Increased Reliance on Non-DoD Organizations | Conduct market research/analysis of the national base of technology | Understand basic market research techniques | Emphasis needs to shift to enhance market research and analysis techniques |
| | | Know technology for a specific business sector. Understand and evaluate unique conditions. | Critical for those in labs and centers |
| | Assess and match DoD/Non-DoD technical and facility capabilities (retain Smart Buyer Expertise in DoD-unique areas. | Know and understand technology insertion strategies and ability to apply to DoD needs. | Critical |
| | | Know DoD's unique technical and facilitation requirements | Critical skill for those in DoD Labs and Centers. Current training needs to be expanded |
| | | Assess the alternative sources and methods most appropriate to handle the requirements not unique to DoD. | Critical skill for those in DoD Labs and Centers. Current training needs to be expanded |
| | | Know, understand and be able to benchmark and evaluate all RDT&E options/ practices | Critical skill for those in DoD Labs and Centers. Current training needs to be expanded |
| | Identify appropriate agreement method/vehicle (CRDA, MOA, etc.) to ensure DoD's interests are protected | Evaluate the individual situation and select the appropriate contracting or assistance vehicle | Have knowledge and understanding of appropriate contracting or assistance vehicle. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Understand the applicability and advantages of the various contracting or assistance vehicles. | |
| | | Know and understand dual use application of program/item needs and ability to incentive dual-use focus | |
| | | Determine the most appropriate agreement, as well as pricing and facility arrangements that will mitigate risk in accordance with regulations, statutes and sound business judgment | Training emphasis needs to be placed in this area. Critical for S/E in Labs and Centers |
| Early Involvement of Operational Test and Evaluation | Develop Test and Evaluation Master Plan (TEMP) to allow for early involvement of T&E | Determine where in the Test & Evaluation (T&E) process testing can be combined to ensure greater participation by the Operational Testers up front while maintaining their independence. | |
| | | Understand responsible agencies for Developmental Test & Evaluation (DT&E), Operational Test & Evaluation (OT&E), and identify the major objectives and types of development and operational testing | Training emphasis needs to be placed in this area. Critical for S/E in Labs and Centers. |
| | | Know, understand and be able to operate in an Integrated Product Team (IPT) environment | Training emphasis needs to be placed in this area. Critical for S/E in Labs and Centers. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Define the test team structure and their contributions in the Test & Evaluation Master Plan (TEMP). Know how the TEMP is used as an integrating document supporting the acquisition strategy throughout the entire acquisition life cycle | Training emphasis needs to be placed in this area. Critical for S/E in Labs and Centers. |
| | Perform design tradeoff's earlier in the acquisition process. | Know, understand and be able to assess design tradeoffs | Critical to engineering |
| | | Evaluate use of the systems engineering process to reduce risk of operational / support problems | Critical to engineering |
| | Develop strategy to minimize operation/support problems, risks and fielding issues | Understand the impact of design on the operations and test environment | Critical to engineering |
| | Plan appropriate T&E of commercial and NDI items. | Know propose use of Commercial & Non-Developmental Items (NDI) be able to evaluate such items. | Shift training emphasis to commercial /NDI requirements. Critical to engineering. |
| | Apply integrated product and process development | Understand the use of Integrated Product and Process Development (IPPD) in successful acquisition management | |
| | Develop verification / conformance metrics | Be capable of developing strategic, tactical and local metrics with in the acquisition process. | |
| | | Know and understand metric development and linkage to mission/operations and cost implications | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Integrate verification/performance metrics into the appropriate contacting or assistance vehicle | Knowledge only. |
| | | Know and understand use of Technical Performance Measures and their impact on cost and ability to meet contract technical requirements | |
| Increased Use of Simulation Based Acquisition (SBA) | Perform analysis on most appropriate SBA program application, select pilot programs. | Know and understand potential DoD/Service growth areas for application of Simulations Based Acquisition (SBA) and Modeling (specifically O&S) | Critical for engineering; Training emphasis needs to be placed in M&S area. |
| | | Understand the use of Modeling and Simulation (M&S) across the total life cycle of a system | Critical for engineering; Training emphasis needs to be placed in M&S area. |
| | Use SBA to identify and simulate design issues and risks | Ensure risk profile are analytically determined using proper methods | Critical for engineering; Training emphasis needs to be placed in M&S area. |
| | | Understand the factors that make up the simulation model and verify that logical and statistical relationship exits. | Critical for engineering; Training emphasis needs to be placed in M&S area. |
| | | Understand and determine how to apply Modeling and Simulation (M&S) when conducting performance studies, effectiveness studies, tradeoff analysis, risk analysis, sensitivity analysis and cost analysis | Critical for engineering; Training emphasis needs to be placed in M&S area. |
| | Apply simulation and modeling techniques | Be capable of using and understanding the basic tenets of modeling and simulation | Critical for engineering; Training emphasis needs to be placed in M&S area. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand the types of models (physical, mathematical, logical) and the common pitfalls and limitations | Critical for engineering; Training emphasis needs to be placed in M&S area. |
| | | Understand the methods and simulations associated with the processes of requirements generation, program management, design and engineering, manufacturing, T&E, logistics support and training | Critical for engineering; Training emphasis needs to be placed in M&S area. |
| Separation of Tech Maturation From Product Development | Perform S&T strategic planning | Know and understand future technological advances that can be incorporated into system development programs. | Critical for SEs. Incorporate S&T planning process in training. |
| | | Know and understand strategic planning tools and techniques. Coordinates with Joint War fighting requirement. | Critical for SEs. Incorporate S&T planning process in training |
| | Conduct risk assessment, risk reduction and mitigation techniques at the earliest possible stage | Know and understand contingency planning and execution | |
| | | Assess technological opportunities and evaluate the feasibility, maturity, and risk. | Critical for SEs. Training emphasis on current tech. |
| | | Know and understand current and future science and technology research and development | Critical for SEs. Training emphasis on current tech. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand risk reduction and risk assessment processes for acquisition process. Balancing risks and benefits in situations involving human safety, environmental risks, and financial uncertainties. | Critical for SEs |
| | Develop realistic Technology Transition Plans. | Convert Technology Transition Planning into effective and executable contract language | Knowledge only |
| | | Know and Planning, Programming and Budgeting System (PPBS) environment and budgeting process for insertion of out year funds for transition | Knowledge only |
| Separation of Tech Maturation From Product Development | Develop realistic Technology Transition Plans | Know and understand technology transition planning / strategy and ability to assess / evaluate and synthesize best-value options into Technology Transition Plans | |
| | | Understand the risks associated with current technology maturity in relation program needs | |
| | Design Systems with open architectures | Know and understand open architecture discipline, tools, and methods and ability to apply to service interoperability | Critical for SEs |
| | Conduct affordability assessments/ analysis. | Be able to do parametric analyses | Shift training emphasis to performing Parametric Analysis. Critical for engineering |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Understand the Cost as an Independent Variable (CAIV) policy concerning the authority of the program manager to make cost and performance tradeoffs | Knowledge and understanding of CAIV policy |
| | | Know and understand affordability assessment techniques and tools | |
| | | Understand theory and applications of Integrated Product and Process Development (IPPD) for S&T programs that are expected to transition to the next phase of acquisition. Understand how to manage, conduct and participate in Integrated Product Teams (IPTs). | |
| | Assess cost/schedule risk and influence on design | Know, understand and be able to perform / evaluate cost/schedule risk assessment | Critical skill required |
| | | Know manufacturing cost implication resulting from product designs | Training emphasis on this area. Critical skill |
| | | Know Cost as an Independent Variable (CAIV) | |
| | | Be able to determine, through the use of risk matrices, templates, or maturity models, the influence of design on risk | |
| | Match evolutionary requirements with mission needs. | Assess technological opportunities an evaluate the feasibility, maturity and risk. | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Understand how to incorporate a trade study methodology, conduct an analysis and provide rationale which address tradeoffs for system requirements | Critical skill required |
| | Assess supportability techniques for assessing systems requirements | Use systems engineering processes to reduce risk of operational and support problems. | Critical skill required |
| | | Manage experimentation and prototyping | |
| | | Know and understand supportability analysis tools and techniques | Training emphasis on supportability analysis tools. Critical skill required |
| | | Identify the impact of reliability, availability, maintainability on system support and ownership costs. | Shift training emphasis in this area to address TOC impacts. Critical skill required. |
| | Identify sources and methodologies for technology insertions | Understand commercial and military state of the art technology applications. | |
| | | Know and understand open architecture discipline, tools, methods to improve aging systems/platforms O&S (specifically for tech insertions) | Critical for SEs at labs and centers |
| | | Know methodologies for inserting technology upgrades and maintaining technical currency | |
| | Apply Advanced Concepts and Technological Demonstrations (ACTDs) as appropriate during product development | Know and understand the Advanced Concepts and Technological Demonstration (ACTD) process and their impact on Life Cycle Cost (LCC) | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| Increased emphasis On Interoperability As A KPP | Develop systems using International Interoperability Standards. | Understand the increased emphasis of interoperability as a Key Performance Parameters (KPP) and ensure it is reflected in the solicitation | |
| | | Negotiate in the international political and business practices environments | Knowledge only |
| | | Identify and describe basic principles of technical standards as they relate to system development and interoperability | |
| | Comply with Joint Technical Architecture requirements | Knowledge and understanding ability to comply with Defense Information Infrastructure Common Operating Environment (DII COE) | Knowledge only |
| | | Understand and apply Joint Technical Architecture (JTA) requirements and standards | Knowledge only |
| | Perform an Interoperability Performance Analysis. | Perform analysis to identify linkages connections, processes and delay time that effect interoperability. | Knowledge as opposed to perform |
| | | Understand framework to look at interoperability through layers such as process, software, information and influences | |
| | Perform a Cost as an Independent Variable (CAIV) analysis. | Understand the purpose and general method of execution of Cost as an Independent Variable (CAIV) | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Prepare and defend a Cost as an Independent Variable (CAIV) analysis. Discuss the relationship of CAIV analysis to other cost analysis | |
| | | Understand the Cost as an Independent Variable (CAIV) policy concerning the authority of the program manager to make cost and performance tradeoff | |
| Increased Emphasis On Software Development | Develop evaluation and assessment criteria to measure software progress | Know and understand software evaluation and assessment criteria | Critical for engineers working software Knowledge area for others. |
| | | Understand and apply the software process development capability | Critical for engineers working software. Knowledge area for others. |
| | | Know and understand customer/system integration requirements to design effective software measures | Critical for engineers working software. Knowledge area for others. |
| | | Understand Capability Maturity Models (CMM) | Critical for engineers working software. Knowledge area for others |
| | | Know software engineering principles and how it applies through the acquisition life cycle. | Critical for engineers working software. Knowledge area for others. |
| | Apply parametric analysis for estimating cost. | Know and understand parametric analysis and ability to perform and analyze resulting data | Critical for engineers working software. Knowledge area for others. |
| | | Understand parametric analyses and construct these analyses to support bid and solicitation development | Critical for engineers working software. Knowledge area for others. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | Apply newly developed software evaluation tools | Know evolutionary spiral process as a Framework for systems and software development programs. | Critical for engineers working software Knowledge area for others. |
| | | Understand parametric analyses and construct these analyses to support bid and solicitation development | Critical for engineers working software. Knowledge area for others. |
| | | Know evolutionary spirals process as a framework for systems and software development programs. | Critical for engineers working software Knowledge area for others. |
| | | Know and understand software acquisition risk for systems, select appropriate mitigation strategies | Critical for engineers working software Knowledge area for others. |
| | | Understand the software development and integration process and the impacts to the software technical life cycle | Critical for engineers working software. Knowledge area for others. |
| | | Know and understand the integrated Capability Maturity Models (CMM) process and how it applies to software development | Critical for engineers working software, Knowledge area for others. |
| | | Know and understand leading/ state of art software evaluation “best practices” and resources for software test program planning and execution | Shift training to state of art evaluation best practices. Critical for S/W engineering |
| | | Be able to use and illustrate state of art tools and techniques available for planning, measuring and predicting software development progress | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| O&S Consolidation | Take joint or corporate approaches to DoD sustainment issues (corporate contracts, standard corporate information systems.) | Know and understand environmental rules/regulations | Knowledge only |
| | | Know and understand environment assessment to law, policy, regulations, community impact and issues/impediments to | Knowledge only |
| | | Know and understand commercial best practices | Knowledge only |
| | Perform / Assess business case analysis (mission, capabilities, costs, trends, opportunities.) | Know and understand risk assessment methods and measurement tools | |
| | | Know and understand Business Case Analysis (BCA) process/rules and tools | |
| | Develop streamlining and implementation planning for consolidation | Know and understand organizational processes and measurement | Knowledge only |
| | | Know and understand personnel policies / procedures to include labor relations/union coordination | Knowledge only |
| | Ensure highest quality staff infrastructure is maintained | Know and understand available training/education resources to include funding/ opportunity | |
| Reengineer the Product Support Process to Use Best Practices | Benchmark government and industry to identify, adopt, and tailor best practices | Know and understand commercial best practices | Knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand analyzing lessons learned, particularly from recent reengineering efforts. | |
| | | Know and understand benchmarking | Knowledge only |
| | | Know and understand research methods literature, internet, corporate assets | Knowledge only |
| | Perform business case analysis | Know and understand Business Case Analysis (BCA) process/rules and tools | Knowledge only |
| | Involve customers early in the acquisition strategy process | Be able to identify and correct potential imbalances in level playing field involved in public-private competitions | |
| | | Know and understand acquisition process | |
| | | Know and understand the Planning, Programming and Budgeting System (PPBS) | |
| | | Understand operating systems that effectively connect operations with customers, distribution channels, and suppliers | Knowledge only |
| | Employ/Develop sourcing strategies that emphasize best value | Know and understand customer requirements | |
| | | Ability to develop performance-based work statements or statements of objectives | Critical for those developing work statements otherwise, knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand risk assessment techniques measurement tools, cost benefit analysis, and fault tree methods for describing and making decisions | |
| | | Know and understand current product support processes and interrelations | Knowledge only |
| | | Know and understand commercial best practices | Knowledge only |
| | | Know and understand data analysis to include cost//performance tradeoffs in order to achieve affordable readiness | |
| | Develop performance-based work statements or statements of objectives | Know and understand product /service to be supported | Knowledge only |
| | | Know and understand performance-based work statements or statement of objectives development / environment | Critical for those developing work statements otherwise knowledge of |
| | Develop incentives for public and private sources to provide sustainment support in a timely and efficient manner while reducing TOC | Know and understand process change enablers | |
| | | Know and understand components of Total Ownership Cost (TOC) | Critical skill required |
| | Apply integrated supply chain practices | Seek integrated Supply Chain Management (SCM) solutions | Knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand ways to apply Single Process Initiative (SPI) to optimize logistics operations | Knowledge only |
| | | Know and understand Supply Chain Management (SCM) purposes and processes – components and total | Knowledge only |
| | | Apply Supply Chain Management (SCM) processes/ methods to business opportunity/ situation | Knowledge only |
| Expansion of Prime Vendor/ Virtual Prime Vendor /PV-VPV like arrangements | Analyze markets not currently covered by prime vendor-type arrangement, and develop acquisition strategies | Know and understand commercial practices, including best practices of specific market sector | Knowledge only |
| | Tailor the application of best practices to the specific market sector and envelop appropriate contractual vehicles | Know and understand commercial best practices | Knowledge only |
| Increased Contractor Logistics Support | Develop integrated support strategies | Know and understand common support requirements and tools and ability to leverage those opportunities…consolidated design and buying opportunities | |
| | | Know and understand sustainment/war reserve requirements | Knowledge only |
| | | Know and understand alternative logistics support risks, costs, and performance in development of integrated support strategies and tools. | Knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
| --- | --- | --- | --- |
| | | Know and understand sustainment processes/techniques and process interrelationships (specific emphasis on inventory management with a configuration management subset | Knowledge only |
| | Develop and apply rules and tools to help determine the best application of contractor support and best use of innovative contracting techniques for common support requirements. | Know how to develop and apply rules and tools to help determine the best application of contractor support and best use of innovative contracting techniques for common support requirements. | Knowledge only |
| Outsource Equipment Disposal Activities | Conduct capability/environmental assessment. | Know how to identify hazardous property and recognize the existence of federal, state and local requirements that may impact on its disposal in accordance with NEPA, RCRA, TSDA, FAR AND DFARS. | Additional training emphasis on this area. |
| | | Know and understand environmental regulations and cost assessments. | Knowledge only |
| | Assess contractor's security processes and procedures. | Know demilitarization requirements to assure resale of surplus material eliminates potential of hazardous/safety incidents. | Critical for engineering involved in safety. Training emphasis needs to occur in this area |
| Increased Use of Vendor Managed Inventory, Direct Vendor Delivery, and Time-Definite Delivery | Use mature, robust, market-ready commercial capabilities with end-to-end visibility of inventory. | Understand and apply past performance in structuring of a solicitation. | Knowledge only |
| | | Know and understand current, market-ready commercial practices with end-to-end visibility of inventory. | Knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
| --- | --- | --- | --- |
| Increased PM Influence to Reduce TOC (with specific emphasis on funding issues) | Emphasize life-cycle cost implications in all program management phases and decisions. | Know and understand life-cycle management processes and phases. | |
| | | Understand Cost as an Independent Variable (CAIV). | |
| | | Know and understand contracting options available. | |
| | | Know and understand formal and informal organizational structure to generate best value solutions to reduce Total Ownership Cost (TOC) | |
| | | Know and understand weapon system/platform mission/operating environment. | |
| | | Analyze market research/customer requirements/sourcing strategies to synthesize best value solutions. | |
| | | Know and understand risk assessment techniques and measurement tools. | |
| | | Know and understand commercial Total Ownership Cost (TOC) and life-cycle practices and tools. | |
| | | Know and understand the Planning, Programming and Budgeting System (PPBS) and defense fiscal management policies and practices. | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand Total Ownership Cost (TOC) variables and impacted areas, to include how to perform tradeoff analyses of capability performance and life-cycle cost drivers and evaluation. | |
| | Develop or modify oversight processes and analysis tools. | Know cost estimating methods. | |
| | | Know which funding accounts the Program Manager must influence to reduce Total Ownership Cost (TOC). | |
| | | Know and understand commercial industry analysis tools and oversight processes. | |
| | | Know cost models, contractor systems and process risks. | |
| | | Understand operating and support cost data and data sources (e.g., Service VAMOSC Systems) and their differences; cost estimating tools/models and their limitations. | |
| | | Know and understand existing oversight processes and analysis tools. | |
| | | Understand Total Ownership Cost (TOC) from several O&S perspectives (e.g., weapon systems, units and organizations). | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | Perform trade-off analysis of capability, performance, and life-cycle cost considerations. | Know and understand life-cycle management processes and phases. | Knowledge only |
| | | Know and understand contingency planning through plan development and implementation. | Knowledge only |
| | | Know and understand analysis techniques and tools. | Knowledge only |
| | | Analyze market research/customer requirements/sourcing strategies to synthesize best value solutions. | Knowledge only |
| | | Know and understand contract incentives/disincentives through contract completion. | Knowledge only |
| Use of Electronic Commerce and Other Information Technology | Use web-based acquisition systems (e.g., electronic catalogs, DoD E-Mail) | Know and understand electronic business environment (e.g., Internet, Word Wide Web and Intranet Tools and Applications) | Knowledge only |
| | Require business partners to apply electronic commerce techniques and tools. | Understand DoD electronic commerce policy. | |
| | | Know and understand marketing/selling methods and strategies. | |
| Increase Competitive Sourcing of Services | Determine acquisition strategy (e.g., regional, omnibus). | Know and understand strategic planning. Know how to develop acquisition strategy. | |
| | Conduct Best Value Analysis on services/cost. | Know and understand Best Value Analysis and understand how to apply in source selections. | Knowledge only. Critical for those involved in source selections. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| Integrated Digital Environment | Leverage commercial technology to support modern business operation (e.g., virtual office | Know and understand hardware, software, and network requirements and applications and interoperability. | Knowledge only |
| | | Know and understand Internet, World Wide Web and Intranet Tools and Applications. | Knowledge only |
| | | Know and understand electronic commerce system relationship to existing business process and their interrelationships. | Knowledge only |
| | | Know, understand and be able to apply business process reengineering. | Knowledge only |
| | | Know and understand statutory/regulatory environment | Knowledge only |
| | | Know and understand marketing/selling methods and strategies. | Knowledge only |
| | | Know and understand performance metrics. | Knowledge only |
| | | Know and understand enterprise resource planning concepts and solutions. | Knowledge only |
| | | Know and understand commercial electronic commerce processes | Knowledge only |
| | | Develop affordable requirements document for establishing software/hardware architecture for Integrated Digital Environment (IDE) | Critical for those generating requirements. |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | Use commercial standard reference identification number system to simplify with private and federal sectors (e.g., Central Contractor registration). | Know and understand unique software requirements and applications. | Critical for those working S/W requirements. Knowledge for all others. |
| | | Know, understand and be able to incorporate standards into paperless operating systems of commercial standard reference identification number system. | Knowledge only |
| | Apply existing national and international standards, practices and technologies to automate the management and exchange of information | Know and understand national and international standards, practices and technologies used to automate and manage and exchange information. | Knowledge only. Critical for those working standards program. |
| Achieve Paperless Contracting | Use electronic mediums for electronic payments. | Know and understand electronic mediums for electronic payment. | Knowledge only |
| | | Know and understand strengths and weaknesses of integration | Knowledge only |
| | | Recognize Government and commercial cultures to effectively educate/market/encourage commercial participation | Knowledge only |
| | Use purchase cards, electronic catalogs, electronic commerce and imaging. | Recognize statutes, rules, policies, and procedures. | Knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| Introduction and Maturation of Knowledge Management Techniques and Practices | Improve data management and availability (within government and between government and industry). | Know, understand and be able to evaluate and apply knowledge and data management tools and techniques to paperless acquisition. | Knowledge only |
| Security/Proprietary Information | Use adequate security measure (to include protocols) to protect electronic information, as appropriate, and to provide ready access. | Know and understand security statutory/regulatory environment | Knowledge only |
| | | Know and understand adequate security measures. | Knowledge only |
| Increased Commercial Military Integration | Promote use of commercial items | Perform advanced market research of commercial and military products | As it applies to SPRDE, only the performance of basic market research should be expected. |
| | | Know, understand and be able to understand benefits of opportunities of using/transitioning to commercial items where available. | Knowledge only |
| | | Know and understand commercial and MILSPEC systems and specific sector practices; ability to develop solutions and deconflict to eliminate military specifications where commercial products and practices fulfill the requirement. | Knowledge only |
| | | Know Part 12 and the direct impact on insight and business/technical processes relationship with defense contractors. | Critical skill |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know operational organizations, concepts and data sources. | Knowledge only |
| | | Perform an analysis of alternatives. | Critical Skill |
| | | Analyze/challenge requirement in order to accept commercial items. | Critical Skill |
| | | Develop and maintain knowledge of the commercial/industrial/academic sectors. | Critical for S&E |
| | Participate in sector activities (e.g., professional associations) | Know and understand sector resources, activities, world-class practices, process, technologies, and integration impediments. | |
| | | Be able to synthesize Government and commercial cultures to effectively educate/market/encourage commercial participation in CMI. | Knowledge only |
| Increased Use of Common Business Practices | Promote use of common business practices | Know and understand benchmarking methods and tools. | Knowledge only |
| | | Know and understand industry data exchange programs. | This is GIDEP |
| | | Identify and adapt common and/or better practices. | |
| | | Know and understand warranties/guarantees and ability to synthesize into Government system. | |
| | | Apply and/or tailor commercial business sector practices (e.g., Single Process Initiative (SPI)). | Knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Perform advanced market research of commercial and military products. | |
| Employ Common Technology Bases | Promote knowledge of world-class technology bases | Know and understand potential DoD/Service growth areas of application of CMI/technology bases (specifically O&S). | Critical for SEs directly involved. Knowledge only for others |
| | | Develop knowledge of relevant technology bases, resources, and capabilities. | Critical for SEs directly involved. Knowledge only for others |
| | Participate in technology sector activities. | Know and understand sector resources, activities, world-class practices, processes, technologies, and integration impediments. | Critical for SEs |
| | | Know and understand dual0use application of program/item needs and ability to incentives dual-use focus. | Critical for SEs involved in tech transition and dual use programs. |
| Employ Flexible manufacturing (Economic manufacture of Varying Size and Types) | Employ flexible manufacturing | Know and understand flexible manufacturing techniques and tools (e.g., CAD/CAM) | |
| | | Evaluate adequacy of workload planning. | Knowledge only |
| | | Evaluate adequacy of contractor manufacturing capabilities | Knowledge only |
| | | Know and understand agile manufacturing | Knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand surge manufacturing and ability to develop best solution for CMI when factoring in surge requirements | Knowledge only |
| | | Know and understand Diminishing Manufacturing Sources (DMS) commodities | |
| | | Know and understand and ability to evaluate adequacy of government/contractor manufacturing capabilities/flexible manufacturing tools. | Knowledge only |
| | Coordinates supply chain requirement (consider and integrate all phases in manufacturing flow). | Know and understand Supply Chain Management (SCM) practices and tools. | Knowledge only |
| | | Be able to develop and evaluate Supply Chain Management (SCM) options for CMI | Knowledge only |
| Extend MILSPEC/ MILSTANDARD Reform to Re-procurements | Reduce MILSPEC/MILSTANDARDS in re-procurements | Develop performance-based specifications. | Critical for SEs |
| | | Know, understand and be able to determine if CMI or military spec is applicable…safety/health/mission needs. | Critical for SEs |
| | | Develop sources as required. | Critical for SEs |
| | | Know and understand quality and testing needs/requirements | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand customer requirements | |
| | | Perform market analyses. | |
| | | Manage multiple configurations. | |
| | | Know and understand commercial and MILSPEC systems and specific sector practices; ability to develop solutions and deconflict to eliminate military practices fulfill the requirement | |
| Life Cycle/Reduced Total Ownership Cost Emphasis | Reduce Life Cycle Cost/Total Ownership Cost | Apply Cost as an Independent Variable (CAIV) and reduced Total Ownership Cost (TOC). | |
| | | Identify, analyze and manage Life Cycle Cost (LCC) drivers. | |
| | | Know and understand cost analysis and life-cycle management. | |
| | Establish activity based costing for the life cycle process. | Comprehend DoD's corporate implementation f activity based costing and management | |
| Evolutionary Acquisition/Reduced Cycle Time | Promote evolutionary and incremental acquisition as appropriate | Perform risk analysis. | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know, understand and be able to assess, evaluate and synthesize evolutionary/incremental enablers (e.g., open architecture, interoperability, CMI, ACTD, technology insertion into comprehensive, cost-effective solution. | |
| | | Assess and forecast technology maturation for system insertion. | |
| | | Analyze and evaluate requirements for validity of evolutionary and incremental acquisitions. | |
| | Minimize cycle time | Evaluate technology maturation to support short cycle time in produce development. | |
| | | Know and understand benchmarking/metrics analysis and ability to apply and evaluate in acquisition process to baseline and reduce cycle time. | |
| | | Understand technology maturation vs. product application. | |
| Flexible User Requirements | Participate in development of user requirements. | Perform risk analysis. | |
| | | Know operational organizations, concepts and date sources. | |
| | | Perform Risk Based Surveillance | Critical Skill |
| | | Know and understand user and joint operating requirements. | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Define and analyze alternatives. | |
| | | Know, understand and be able to operate in Integrated Product Team (IPT) environment. | |
| Technology Refreshment of System (Modernization through Spares) | Promote technology refreshment of systems. | Know and understand inventory management methods and practices and interrelationships to inventory re-procurements. | Knowledge only |
| | | Know, understand and be able to assess, evaluate, and synthesize technology refreshment enablers (e.g., open architecture, interoperability, CMI, ACTD, technology insertion into comprehensive, cost-effective solution) | |
| | | Assess and forecast technology maturation. | |
| | | Apply open systems architectures. | |
| | | Know and understand interchangeability/interoperability and substitution. | |
| | | Identify, analyze and manage Life Cycle Cost (LCC) drivers. | |
| | Develop performance based specifications | Know, understand and be able to use engineering change process methods and tools. | |
| | | Know, understand and be able to use value engineering methods and tools. | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Know and understand motivation techniques to incentivize to develop product improvements | |
| | | Evaluate performance-based work statements and advise program office as appropriate. | |
| | Obtain and execute funding for modernization. | Synthesize the functions of the Planning, Programming and budgeting System (PPBS). | Knowledge only |
| Increased Scope of Other Transactions | Expand use and scope of other transactions. | Manage/overseas other transactions. | |
| | | Know and understand potential DoD/Service growth areas for application of other transactions (specifically O&S). | |
| | | Define, select and adapt terms to the specific agreement. | |
| | | Perform advanced market research. | |
| | | Know, understand and be able to access/evaluate and synthesize data of Other Transaction Authority (OTA) low/policy/resources. | |
| Increased use of Best value-Dissimilar Competition | Expand use of best value and dissimilar competitions including capabilities tradeoff vs. mission. | Develop performance based solicitation. | |
| | | Apply modeling and simulation techniques. | |
| | | Analyze expected system performance outcomes for best value. | |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Analyze user requirements. | |
| Increased Use of Performance Based Contracting | Capitalize on opportunities to develop performance based solicitations for products and services. | Develop performance expectations incentives and metrics to describe acquisition needs and evaluate outcomes. | |
| | | Know and understand sector resources and activities. | |
| | | Know and understand common business practices. | |
| | | Know and understand world-class sector practices processes and technologies (e.g., Single Process Initiative (SPI)). | |
| Increased Collaboration Between User and Acquisition Communities | Promote collaboration between user and acquisition communities | Know and understand the Integrated Product Team (IPT) environment. | |
| | | Be able to synthesize Government and commercial cultures to effectively educate/market/encourage collaboration between user and acquisition communities. | Knowledge only |
| | Promote collaboration between user and acquisition communities. | Know and understand collaboration impediments. | Knowledge only |
| | | Develop mutual understanding of user roles and functions and the acquisition system capabilities. | Knowledge only |
| | | Model and analyze manufacturing system performance. | Knowledge only |

| Environmental Trend | Functions | ID Competency | Comments/Nuances |
|---|---|---|---|
| | | Maintain open communications through all phases of the life cycle. | |

# Appendix J
# Future Acquisition and Technology Workforce Report (April 2000) – Updated Assumptions

## LMI ASSUMPTIONS

*Future Acquisition and Technology Workforce Report* (April 2000)—Updated Assumptions

Institute for Defense Analyses
3 March 2004

### Basis for Your Review of the Following Charts

- IDA is conducting a study to identify relevant SPRDE/SE duties and tasks (competencies) with which to conduct a review of the SPRDE/SE courses
- The Future Acquisition and Technology Workforce Report, published in early 2000, contains certain assumptions (called trends) upon which its lists of competencies are based
- IDA wants to validate, change, or eliminate these various assumptions based on the current environment to determine how to include the identified competencies in their study
- We would like your input

8/6/2004 2

## Overview of the Workforce Report

- Future trends are identified, both global and functional, that will effect what the future workforce will be required to do (functions) and what skills it will need (competencies)
  - ~100 future functions are identified—activities the workforce must perform to implement acquisition reforms and new practices
  - 27 universal competencies and traits are identified as being needed by the entire workforce, to differing degrees depending on job level
  - Over 400 detailed functional competencies were developed, sorted by career field

9/8/2004 3

## First, Environmental Trends drove the Master Functional Competencies

Only those trends that influenced the SPRDE competencies are included in the next 5 slides

## Research Development, Test & Evaluation

- Consolidation (Centers of Excellence)
- Increased reliance on non-DoD organizations
- Early involvement of OT&E
- Increased use of M&S
- Separation of tech maturation from product development
- Increased emphasis on interoperability as a KPP
- Increased emphasis on software development
- Increased reliance on performance-based specs
- Increased emphasis on war fighting "capabilities" vice detailed system requirements

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## Operations & Support

- Consolidation
- Reengineer the product support process to use best practices
- Expansion of prime vendor/virtual prime vendor-like arrangements
- Increased contractor logistics support
- Outsource equipment disposal activities
- Increased use of vendor-managed inventory, direct vendor delivery, and time-definite delivery
- Increased PM influence to reduce TOC (with specific emphasis on funding issue)
- Use of electronic commerce and other information technology
- Increase competitive sourcing of services
- Increasing influence of considerations such as technology refreshment for COTS
- Faster changes in the system physical baselines – re-engineering of the configuration management paradigm
- Emphasis on product quality

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## Move to Paperless Acquisition

- Integrated digital environment
- Achieve paperless contracting
- Introduction and maturation of knowledge management techniques and practices
- Security/proprietary information



## Emphasize Commercial-Military Integration (CMI)

- Increased CMI
- Increased use of common business practices
- Employ common technology bases
- Employ flexible manufacturing (economic manufacture of varying sizes and types)
- Extend MILSPEC/MILSTANDARD reform to re-procurements

## Adopt New Approach to Acquisition

- Life cycle/reduced total ownership cost emphasis
- Evolutionary acquisition/reduced cycle time
- Flexible user requirements--focus on system and warfighter capabilities
- Technology refreshment of systems (modernization through spares)
- Increased use of other transactions
- Increase use of best value-dissimilar competition
- Increased use of performance-based contracting
- Increased collaboration between user and acquisition communities



## Second, additional SPRDE-specific competencies were developed

Based on the following vital competencies and global/functional trends

# SPRDE Vital Competencies

- Ability to operate in an IPPD environment
- Understanding and mastering competencies to control TOC
- Ability to understand and use the SE process to develop balanced system solutions that meet requirements, reduce risk, control cost, and exhibit attributes of robustness throughout the acquisition life-cycle
- Ability to perform parametric analyses for both hardware and software systems
- Understand what M&S tools are available and how to best use them
- Understanding and proper use of open systems and open architectures
- Evaluation, assessment, development, and integration of software products/efforts that support the acquisition of new systems
- Understand how to perform comprehensive risk analyses and risk assessments
- Ability to address Information Assurance requirements throughout the acquisition life-cycle
- Ability to estimate cost

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# Impact of Global/Functional Trends on SPRDE Career Field

- Smaller workforce
- Older workforce
- Information technology
- Knowledge management and learning organization
- Cross-functional teaming and personnel mobility
- Competitive sourcing
- Ever-increasing product complexity
- Pressure for shorter development time
- Need to control costs
- Over-optimism

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## Finally, a vision for SPRDE was developed

The vision is for 2005, and we are now in 2004

## SPRDE Career Field Vision

In 2005 based on the global and functional trends , government engineers will either be part of IPTs or themselves will form small IPTs that cover critical engineering competency areas. The team will be able to operate in a performance-based environment and will have the skills necessary to help customers meet cost, schedule and technical targets. They will have a thorough understanding of, and maintain competency in

- Systems and design engineering
- Risk management
- Logistics
- Test
- Manufacturing
- Quality Assurance
- Modeling and simulation
- Open systems
- Software

And their interactions, integration, and effect on cost, schedule, and technical performance. Engineers will be well versed in commercial, industrial, and academic technology and management developments. Small teams of engineers will be able to react quickly to customer needs, perform the necessary analyses, and make proper recommendations to help preclude or fix technical program, system, or process problems.

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Please direct your comments as to whether these assumptions are still valid and/or whether any changes/additions should be made.

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THANKS

# Appendix K
# SPRDE/SE Duties and Tasks for SYS 101, 201 and 301

## SPRDE/SE DUTIES AND TASKS—SYS 101

These duties and tasks are divided by shaded headings. The major headings are highlighted in dark gray: SE Processes, Design Considerations, and SE Techniques and Tools. The sub-headings are shown in lighter gray.

| SYS 101--The Systems Engineering Processes |
|---|
| Define systems engineering. |
| Know where to go for SE guidance, e.g., PM CoP, INCOSE, guides and handbooks. |
| SE Processes |
| Apply SE processes at the initial stages of program formulation and throughout all phases of the system lifecycle. |
| Apply systems engineering throughout the total system lifecycle. |
| Understand the requirements for early integration of ESOH considerations into SE. |
| Recognize that SE is the process of technical management in the defense environment, and how it is used in translating operational needs and requirements into an integrated system design solution. |
| Relate how SE processes are applied within Integrated Product/Process Development (IPPD) to translate customer needs into system products and processes. |
| Translate the JCIDS-defined capabilities to a system-specific design solution and understand the major goals of this process. |
| Apply the SE processes to transform requirements and constraints into an operational system design. |
| Understand the national and international SE process standards and models and how to use them. |
| Understand the relationship between the process models and the life cycle models (i.e., waterfall, vee, and spiral). |
| Tailor the SE processes in standards or models to the program. |
| Identify the technical and technical management processes of SE as well as the IPTs that apply them. |
| Match key terms associated with the SE processes to their respective definitions. |
| Identify the inputs and outputs of each process. |
| Differentiate among various aspects of the SE processes for each of the following: application consideration and IPT involvement; architecture of a system; levels of development; SE processes applied within the acquisition life cycle; and hardware versus software development/integration. |
| Requirements Development |

| SYS 101--The Systems Engineering Processes |
|---|
| Understand the purpose, inputs and outputs of the Requirements Development process. |
| Analyze capabilities documents. |
| Analyze lifecycle impacts and their relationship to requirements. |
| Identify all lifecycle stakeholders and elicit their requirements. |
| Develop a set of functional, physical, and operational requirement viewpoints in accordance with SE commercial practices. |
| Recognize different sources of inputs and identify various requirement types. |
| Distinguish the attributes of a well-defined requirement and the problems associated with requirements generation. |
| Apply the 15 requirements analysis tasks to a system at all levels of development. |
| Analyze requirements flow down and allocation into specifications. |
| Analyze behavioral requirements and design constraints. |
| Focus on user requirements. |
| Understand the user's perspective and requirements. |
| Conduct requirements development and structure research and development work effort to match user needs. |
| Work with the user to conduct periodic re-evaluation of requirements. |
| Develop requirements in an integrated framework. |
| Requirements Management |
| Understand the purpose, inputs and outputs of the Requirements Management process. |
| Implement a disciplined Requirements Management process from the ICD through the system requirements documents (e.g., ICD to Request for Proposal (RFP) performance requirements document to contract specifications to product specifications,). |
| Link lower level specifications to higher level requirements. |
| Provide traceability from logical groupings (of functions, etc.) to requirements. |
| Formulate plans so as to ensure that functional, design, performance, environment, cost and schedule requirements are being tracked. |

| SYS 101--The Systems Engineering Processes |
|---|
| For each baseline specification, implement program metrics to measure and track the extent of requirements changes in terms of number of requirements' "shall statements" changed from contract award forward through the development cycle. |
| Institute a formal requirements traceability process that begins with the ICD and evolves to include the total system. |
| Document the treatment of the user's interoperability requirements. |
| Require contractors to implement requirements tracking tools and flow down these tools to the subcontractor base to assure completeness. When appropriate, use commercially available software tools to implement the requirements management and tracking process. |
| Logical Solution |
| Understand the purpose, inputs and outputs of the Logical Solution process. |
| Create a behavior model. |
| Develop a functional architecture during the Logical Solution process in accordance with SE commercial practices. |
|     Distinguish among functional analysis, allocation, and functional architecture. |
|     Summarize tools used in the Logical Solution process (functional flow block diagram, timeline sheets, and requirements allocation sheets). |
| Understand the evolution of the functional architecture from the established system requirements. |
| Develop functional specifications. |
| Design Solution |
| Understand the purpose, inputs and outputs of the Design Solution process. |
| Identify solution alternatives (training, doctrine, material, etc.). |
| Analyze alternative design solutions and select one. |
| Translate outputs of the Logical Solution process into system product and process designs which duly consider life cycle issues. |
| Analyze requirements flow down and allocation into specifications. |
| Require completion of the top level system design and requirements allocation to subsystems prior to initiation of the subsystem design activity. |
| Understand the evolution of the physical architecture. |
|     Evaluate/ Select preferred architecture. |

| SYS 101--The Systems Engineering Processes |
|---|
| Allocate functions to physical elements. |
| Analyze industry standards to determine their role in describing the physical architecture of a system. |
| Develop specification trees and specifications. |
| Summarize the tools in the Design Solution process (concept description sheets and schematic block diagrams). |
| Develop a design architecture during the Design Solution process in accordance with SE commercial practices. |
| Identify the inputs and outputs of the Design Solution process. |
| Recognize how the open systems design principles influence the Design Solution process. |
| Recognize how modeling and simulation supports the Design Solution process. |
| Develop the training system architecture. |
| Develop the manufacturing system architecture. |
| Implementation |
| Understand the purpose, inputs and outputs of the Implementation process. |
| Conduct make/buy/reuse analysis. |
| Conduct manufacturing planning. |
| Develop/implement the manufacturing strategy and plan. |
| Determine the major variables and trends encountered in production, and how they relate to other functional areas. |
| Manage/execute acceptance testing. |
| Perform process inspection and product acceptance. |
| Develop documentation for system elements. |
| Integration |
| Understand the purpose, inputs and outputs of the Integration process. |
| Understand/develop individual system/subsystem interface requirements. |
| Establish Interfaces (software/software, hardware/software, human). |

| SYS 101--The Systems Engineering Processes |
|---|
| Require systems level integration and test planning early in the program. |
| Design for the compatibility of all functional and physical interfaces. |
| Define/ refine interfaces as design matures. |
| Conduct system hardware and software integration. |
| Conduct system user interface analysis. |
| Reinforce the importance of specifying, allocating, and controlling interface requirements including interfaces among the members of a System of Systems (SoS)/ Family of Systems (FoS). |
| Integrate, test and modify the physical product from lowest level through system level (test, analyze and fix). |
| Determine and manage the impact of a new system to current, fielded solutions. |
| Verification |
| Understand the purpose, inputs and outputs of the Verification process. |
| Determine that proposed design meets requirements and is achievable within existing programmatic constraints. |
| Verify technical and operational performance against the established baseline in accordance with policy and legislation from the component to the system level throughout the life cycle. |
| Apply the Verification process in order to ensure the system elements meet or exceed their requirements. |
| Identify functions of the Verification process. |
| Differentiate the methodologies for developing, conducting, and analyzing tests throughout the systems acquisition life cycle (e.g., verification, validation, accreditation (VV&A), independent verification and validation (IV&V), metrics, technical performance measurement (TPM), and open systems). |
| Differentiate between the systems verification process and mandatory test and evaluation planning requirements. |
| Conduct design solution verification. |
| Write a verification requirement for each performance requirement “shall statement” and incorporate them into the requirements definition/specification processes. This should take the form of a narrative section four in the specification. (see JACG series of specification guides). |
| Include verification of interface requirements in development and test plans. |
| Identify deficiencies that keep systems from meeting requirements. |

| SYS 101--The Systems Engineering Processes |
|---|
| Validation |
| Understand the purpose, inputs and outputs of the Validation process. |
| Perform requirements validation. |
| Perform Logical Solution and design solution representations validation. |
| Transition |
| Understand the purpose, inputs and outputs of the Transition process. |
| Define transportation, packaging, handling, and storage requirements. |
| Plan and monitor the fielding process. |
| Develop a deployment system architecture. |
| Technical Planning |
| Understand the purpose, inputs and outputs of the Technical Planning process. |
| Determine the sensitivity of interrelated tasks. |
| Differentiate the role of technical planning within the SE effort from overall program planning. |
| Distinguish between program planning and activities of the Technical Planning process. |
| Select control criteria and metrics for the Technical Planning process. |
| Distinguish between event criteria planning and calendar time-based schedule. |
| Distinguish among the following systems design influences: reliability and maintainability; supportability and support; manufacturing and production; human systems integration; test and evaluation; and modeling and simulation. |
| Recognize contractor technical planning and/or execution efforts. |
| Technical Assessment |
| Understand the purpose, inputs and outputs of the Technical Assessment process. |
| Establish measures of performance and effectiveness for proposed material solutions. |
| Understand the key analyses required to ensure that a system meets customer needs and provide a balanced set of products and processes. |
| Assess development programs and identify risks and pitfalls. |

| SYS 101--The Systems Engineering Processes |
|---|
| Assess contractor technical management (e.g. engineering, manufacturing, and quality) systems and processes. |
| Decision Analysis |
| Understand the purpose, inputs and outputs of the Decision Analysis process. |
| Apply quantitative and qualitative tools to support problem solving and decision making in an acquisition environment. |
| Understand group decision making and voting. |
| Determine risk and factor it into the decision process. |
| Provide and document decision rationale. |
| Risk Management |
| Understand the purpose, inputs and outputs of the Risk Management process. |
| Apply the acquisition risk management process within an IPPD environment in order to determine risk. |
| Recognize key risk and risk management policy concepts. |
| Distinguish among the risk management process steps (planning, assessment, handling, and monitoring). |
| Recognize the role of risk management in the DoD acquisition process. |
| Apply the risk management process (plan, assess, handle, and monitor) as a basis for making sound acquisition program decisions. |
| Define and quantify risk, and impacts/benefits of risk management. |
| Assess the interrelationship of technical risk with cost and schedule. |
| Determine alternative approaches for moderate/high risks. |
| Develop/utilize risk management methodologies and tools. |
| Identify methods, tools and techniques for analyzing, documenting, and mitigating/minimizing ESOH risks. |
| Establish/utilize a risk reporting system and tracking techniques. |
| Understand how risk is defined, identified, classified and quantified. |
| Understand risk, levels of risk, risk drivers, and constraints. |

| SYS 101--The Systems Engineering Processes |
|---|
| Include early simulation demonstrations of the reuse candidates in the risk management program as risk mitigation activities. |
| Analyze risk management planning (prototyping, spiral development, evolutionary acquisition, modifications and upgrades). |
| Understand risk mitigation techniques (Non-Developmental Items (NDI), Commercial Off the Shelf (COTS), Technology Area Assessment (TAA), Technology Area Plan (TAP). |
| Reduce the risk of operational/support problems. |
|     Understand how hazard analyses balance the benefits and risks of both ESOH and system performance considerations. |
| Configuration Management |
| Understand the purpose, inputs and outputs of the Configuration Management (CM) process. |
| Determine the role and functions of the Configuration Management process in the acquisition process. |
| Contrast the roles and relationships of configuration management, data management, and interface management. |
| Understand the differences between configuration baselines versus program baselines. |
| Generate configuration baselines and provide technical support for acquisition program baselines. |
| Understand the configuration baselines (functional, allocated, and product), when they are established, and why they are important. |
| Perform baseline management including audits. |
| Understand the four functions of Configuration Management and their inter-relationships. |
| Understand/execute the change process. |
|     Understand the three different kinds of changes within the configuration control function. |
|     Track, approve and control engineering changes. |
| Understand the internal operations of a Configuration Control Board (CCB). |
| Distinguish among CM, CM benefits, CM reference documents, and CM planning, and also identify the four major sub processes of CM. |
|     Differentiate the following configuration identification function elements: configuration items; configuration documentation; configuration baselines; and program-unique specifications. |
|     Apply the following configuration control function elements: Engineering Change Proposals (ECP); Request for Deviation (RFD); and CCBs. |

| SYS 101--The Systems Engineering Processes |
|---|
| Differentiate between the configuration status accounting and configuration audit functions. |
| Manage and communicate changes to systems in all phases of the life cycle. |
| Data Management |
| Understand the purpose, inputs and outputs of the Data Management process. |
| Contrast the roles and relationships of configuration management (CM), data management, and interface management. |
| Define the minimum essential life cycle data requirements. |
| Obtain technical data and trace data to requirements. |
| Understand the relationship of the Contract Data Requirements List (CDRL) to the Data Item Description (DID) and RFP. |
| Ensure the quality of the data. |
| Establish/maintain data management database. |
| Work in an integrated data environment. |
| Interface Management |
| Understand the purpose, inputs and outputs of the Interface Management process. |
| Differentiate the following interface management function elements: Interface Control Working Groups (ICWG) and interface control documentation (ICD). |
| Ensure the integrity of interface controls. |
| Design Considerations |
| Open Systems Architecture |
| Understand open systems architectures, disciplines, tools and methods and application to system interoperability. |
| Document technical approach to using an open systems approach to system design. |
| Promote use of contractor/government-off-the-shelf NDIs. |
| Assess the use of NDI including their constraints, advantages, and disadvantages. |
| Architectures and Interoperability |
| Determine the purpose and timing of architectures over the system life cycle. |

| SYS 101--The Systems Engineering Processes |
| --- |
| Understand/assess standards and interoperability requirements. |
| Define systems of systems and understand their complex organization and management. |
| Ensure that the proposed system functionally operates with other systems, units, or forces, to include U.S. or other coalition partners. |
| Synthesize multiple architectures. |
| Conduct system architecture modeling and analysis. |
| Develop systems using international interoperability standards. |
| Understand the increased emphasis of interoperability as a Key Performance Parameter (KPP) and ensure it is reflected in the solicitation. |
| Identify and describe basic principles of technical standards as they relate to system development and interoperability. |
| Comply with Joint Technical Architecture (JTA) requirements. |
| Understand and apply JTA requirements and standards. |
| Comply with Defense Information Infrastructure Common Operating Environment (DII COE). |
| Perform an interoperability performance analysis. |
| Perform analysis to identify linkages, connections, processes and delay time that affect interoperability. |
| Understand framework to look at interoperability through layers such as process, software, information and influences. |
| Participate in developing integrated architectures for DoD systems and understand the interoperability certification process. |
| Software |
| Recognize the complexity of software development, its integral nature to the SE/ software system safety processes, and top-level "best practices" for successful software development. |
| Define software requirements. |
| Understand the characteristics of a well-defined software requirement. |
| Develop software functionality specifications. |
| Demonstrate "best practices" for the acquisition of a software intensive system. |
| Understand the similarities and differences between hardware and software development. |

| SYS 101--The Systems Engineering Processes |
|---|
| Determine the key processes that should be used by developers to create quality software products. |
| Know software development principles and techniques. |
| Develop evaluation and assessment criteria to measure software progress. |
| Apply newly developed software evaluation tools. |
| Use state of the art tools and techniques available for planning, measuring and predicting software development progress. |
| Commercial Off the Shelf Items and Non Developmental Items |
| Know and understand benefits and opportunities of using / transitioning to commercial items where available. |
| Understand the appropriate documentation and potential ESOH implications during COTS selection. |
| Understand NDI & COTS use to meet technical goals. |
| Conduct SE analyses of the reuse and COTS candidates to determine that the candidates exist in acceptable usable form, that they meet the new system requirements, and that they are well documented and designed for reuse. |
| Develop appropriate T&E strategy for commercial items. |
| Manufacturing Capability and Producibility |
| Understand the producibility concepts and activities throughout the acquisition life cycle phases. |
| Recognize the major producibility goals of the design effort and the DoD quality process which translates a released design to a producible product. |
| Determine the role of manufacturing considerations in the SE processes throughout the acquisition life cycle. |
| Evaluate alternative /new manufacturing processes and capability. |
| Understand industry/commercial approaches to manufacturing innovation, i.e. conversion and reconstitution. |
| Understand manufacturing technology. |
| Conduct producibility studies. |
| Understand producibility issues and how to manage the design for producibility. |
| Understand environmental trade-offs between basic manufacturing techniques. |

| SYS 101--The Systems Engineering Processes |
|---|
| Demonstrate that all critical manufacturing processes are under statistical control and consistently producing items within the quality standards and tolerances for the overall product before production begins. |
| Quality Assurance |
| Plan and operate quality assurance and baseline measurement. |
| Develop system quality requirements. |
| Conduct quality assurance. |
| Reliability, Availability and Maintainability |
| Conduct system reliability, availability, and maintainability analysis. |
| Determine the system maintenance concept and conduct maintenance forecasting and planning. |
| Understand the levels of maintenance and how they affect life cycle costs. |
| Design for reliability, availability, and maintainability. |
| Demonstrate product reliability before the start of production by testing to identify the problems, make design corrections, and retest the new design. |
| Understand the most common methods used to measure reliability and maintainability. |
| Understand the differences and similarities between hardware and software reliability and maintainability. |
| Identify the impact of reliability, availability, maintainability on system support and total ownership costs. |
| Acquisition Logistics and Supportability |
| Determine how acquisition logistics activities impact and relate with other functional areas within the acquisition life cycle. |
| Determine the acquisition logistics support activities and requirements associated with fielding/ deployment and post production support of a system. |
| Prepare logistics planning and execute into technical effort. |
| Recognize the importance of supportability to achieving the system readiness requirements and reducing life-cycle costs. |
| Conduct logistics integration. |
| Understand designing for supportability. |
| Develop or evaluate design changes in response to supportability issues. |

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| Know and understand supportability analysis tools and techniques. |
| Recognize the importance of the 10 support elements in supportability planning. |
| Make critical decisions concerning system supportability. |
| Understand the effects technology has on supportability. |
| Develop training for field users. |
| Prepare logistics planning and execute into technical effort. |
| Conduct supply support planning and develop system supply, support, and spares management. |
| Assess manpower and personnel impacts. |
| Human Systems Integration |
| Understand human and cognitive factors and their affect on the system technical effort. |
| Develop Human System Integration (HSI) requirements. |
| Design for usability, human factors, and human systems integration. |
| Environmental, Safety, and Occupational Health |
| Integrate ESOH considerations in systems acquisition. |
| Describe ESOH statutes, regulations, policies, international agreements, and government/ industry standards and how they affect systems acquisition programs throughout the life-cycle. |
| Identify and describe key ESOH functional areas that should be evaluated for potential ESOH risks to the program and to the users throughout the systems' life-cycle: e.g. National Environmental Policy Act / Executive Order 12114; hazardous materials management/ pollution prevention; and safety and health, to include explosives safety/insensitive munitions, system safety, personnel safety/occupational health |
| Identify and describe the types of ESOH information required in key acquisition documents in accordance with DoD systems acquisition policy; key documents include: RFPs, Contracts, and Government Statements of Work (SOWs); ICD; CDD; CPD; AoA; Acquisition Program Baseline (APB); acquisition strategy; Test and Evaluation Master Plan (TEMP); Cost Analysis Requirements Document (CARD); Programmatic ESOH Evaluation; SEP; HSI plan; Logistics Support Analysis (LSA)/Integrated Logistics Support Plan (ILSP); demilitarization/disposal plans. |
| Conduct ESOH evaluations as delineated in DoDI 5000.2. |
| Provide detailed methods for ESOH and National Environmental Policy Act /Executive Order 12114 compliance. |
| Provide detailed tools and methods to implement system safety, MIL-STD 882D, and occupational health considerations. |

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| Describe the process for identifying hazardous materials management, and the processes for selecting alternatives for use on the system. |
| Provide methods to implement pollution prevention in the program. |
| Understand system safety principles, including identifying, selecting, and evaluating source materials and processes. |
| Assess the impacts of ESOH considerations in the SE processes. |
| Apply historical lessons learned from legacy systems to future systems. |
| Survivability |
| Develop survivability requirements. |
| Corrosion Prevention and Control |
| Conduct corrosion prevention and control planning to derive system requirements. |
| Employ material selection, packaging, and maintenance procedure decisions conducive to corrosion prevention and control. |
| Describe the facilities engineering process and how it relates to the DoD Acquisition Process; describe how a program manager is made aware of facilities engineering issues; describe how facilities engineering issues affect acquisition programs; and describe the funding process for facilities engineering. |
| Disposal and Demilitarization |
| Understand the goals and objectives of disposal and demilitarization and their impact on the SE processes during the development of a weapon system. |
| Information Assurance |
| Assess key information assurance requirements that characterize the current DoD acquisition environment. |
| Incorporate information assurance requirements into system design activities to ensure availability, integrity, confidentiality, authentication and non-repudiation of critical system information. |
| System Security |
| Conduct system security engineering and derive system requirements. |
| Test and Evaluation |
| Determine the role of T&E in the systems engineering and acquisition management processes. |

| SYS 101--The Systems Engineering Processes |
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| Determine the fundamental role of Developmental Test and Evaluation (DT&E) in the acquisition life cycle. |
| Include test and evaluation as a topic in program and design reviews. |
| Assure that there is only one test requirements baseline for the program that all stakeholders use. |
| Understand the differences between DT&E and Operational Test and Evaluation (OT&E) and the various tests associated with the two types. |
| Provide requirements for test management and diagnostic equipment and ground support equipment. |
| Plan appropriate T&E of commercial items and NDI. |
| Recognize:<br>--The different types of T&E.<br>--The organizations responsible for each.<br>--The reason for heavy DoD commitment to T&E.<br>--T&E planning and its function as the essential feedback mechanism for the SE processes. |
| Sustainment |
| Include sustainment as a topic throughout the design process; include sustainment specialists in program planning activities. |
| Systems Engineering Techniques and Tools |
| Understand SE tools and methods, e.g., TPM, IDEF, Statistical Process Control, Quality Function Deployment, N2, Pareto and other charts, influence diagrams, critical path analysis. |
| Understand Functional Flow Block Diagrams (FFBDs), timeline sheets, and requirements allocation sheets. |
| Understand the documentation tools available (e.g. concept description sheet and schematic block diagrams). |
| Understand design technologies and tools to include: Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM), and Universal Modeling Language (UML). |
| Understand the activities, tools and documentation for integrating ESOH considerations into the SE processes. |
| Systems Engineering Plan |
| Develop/coordinate and implement the SEP. |
| Relate the similarities and differences between the government and contractor SEP. |

| SYS 101--The Systems Engineering Processes |
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| Reflect acquisition strategy in government SEP. |
| Understand how program political and budget issues may influence the SEP. |
| Establish a SEP early in the program definition, and update it continuously as the program matures, through system operations and support. |
| Document in the SEP a description of the systems engineering integration on program IPTs including resources, staffing, management metrics and integration mechanisms. |
| Describe how the processes will be implemented and how they will be tailored to meet individual acquisition phase objectives. |
| Describe how the SE processes will support the technical and programmatic products required of each phase. |
| Describe how the technical baseline will be developed, managed, and used to control system requirements, design, integration, verification, and validation. |
| Describe metrics (e.g., technical performance measures) for the technical effort and how these metrics will be used to measure progress. |
| Describe how systems engineering activities will be integrated within and coordinated across IPTs; how the IPTs will be organized; what SE tools they will employ; and their resources, staffing, management metrics, and integration mechanisms. |
| Describe how SE processes are integrated in the program's overall integrated schedules. |
| Work Breakdown Structure |
| Recognize the inherent power of a well-designed Work Breakdown Structure (WBS) and its application throughout the SE processes. |
| Relate the physical or system architecture and specifications to the WBS. |
| Develop a WBS based on a given physical architecture. |
| Distinguish among three uses of the WBS (organizational, business, and technical) and be able to recognize various types of work breakdown structures. |
| Understand the derivation and multiple uses (e.g. Cost Performance Reporting (CPR) system, work package relationship, SOW relationship, and the primary functions utilization) of the WBS. |
| Recognize how the IPTs are organized using the WBS. |
| Recognize how the design (or physical) architecture, specification tree, and system architecture support the WBS. |
| Integrated Master Plan/Schedules |

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| Require that the Integrated Master Plan (IMP) has well-defined accomplishments with entrance and exit criteria for program milestones and events. |
| Ensure that the Systems Requirement Review (SRR) is a key event in the IMP with exit criteria that assures the system specification is complete, including a complete set of verification requirements. |
| Map the SE processes defined in the program SEP to the IMP, including entrance and exit criteria for the program reviews and events. Specifically identify SE task completions as entrance and exit criteria. |
| Evaluate the IMP and Integrated Master Schedule (IMS) for T&E planning realism during the source selection. |
| Require the offeror to propose a system level IMP and IMS. Evaluate these products during source selection to ensure that the key SE and engineering development events have appropriate entry level criteria and that the planned SE task durations are adequate. |
| Keep the system IMP/IMS at the appropriate level by focusing on key gating events and important criteria. |
| Establish subsystem IMP/IMS as appropriate and flow the requirement to subcontractors and vendors as appropriate. |
| Enforce the criteria included in the IMP; don't gloss over event and accomplishment exit criteria. |
| When actions are needed to close criteria partially met, establish near term follow-up plans to assure the actions are completed and the IMP criteria are fully met. |
| Value Engineering |
| Know, understand and be able to use value engineering methods and tools. |
| Technical Performance Measurement |
| Define effectiveness measures. |
| Determine the role of TPMs in the SE processes. |
| Determine how TPMs will be captured in the SEP. |
| Understand how technical parameters/TPMs are applied to performance-based progress measurement in SE. |
| Understand performance based management. |
| Compare performance achievements to date with plan. |
| Develop new/modified performance goals. |
| Develop recommended approach for TPM. |
| Manage technical performance measure variances. |

| SYS 101--The Systems Engineering Processes |
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| Understand the conceptual basis and relevant terms for TPM charts and how they are linked to critical Measures of Performance (MOP). |
| Develop TPMs when given a set of system requirement descriptions. |
| Recognize the performance measurement requirements. |
| Understand relevant terms identified within TPM charts. |
| Analyze a TPM chart to determine the necessary management action. |
| Determine criteria and timing for selecting TPMs. |
| Know and understand use of TPMs and their impact on cost and ability to meet contract technical requirements. |
| Trade Studies |
| Conduct trade studies using system simulations where appropriate and document results. |
| Understand the key alternatives or tradeoffs made as the system evolves from the conceptual level of development to the detailed subsystem level of development. |
| Understand lifecycle trade study techniques and methods. |
| Understand the role of trade studies in the development of functional and performance requirements. |
| Propose a trade study methodology, conduct an analysis in accordance with SE commercial practices. |
| Understand where, when, and how (methodology) trade studies are used within the SE processes to resolve conflicting requirements. |
| Recognize how trade studies balance system life cycle concerns. |
| Recognize the role of effectiveness analyses in support of trade studies. |
| Modeling and Simulation |
| Use Modeling and Simulation (M&S) throughout the life cycle of a system and assess the contractor's use of M&S. |
| Apply M&S to identify and simulate design issues and risks. |
| Understand and determine how to apply M&S when conducting performance studies, effectiveness studies, tradeoff analysis, risk analysis, sensitivity analysis and cost analysis. |
| Plan and accomplish early simulation demonstrations, prior to Preliminary Design Review (PDR), of the reuse candidates on system simulations, i.e., verify the reusability early. |
| Be capable of using and understanding the basic tenets of M&S. |

| SYS 101--The Systems Engineering Processes |
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| Know and understand the types of models (physical, mathematical, logical) and the common pitfalls and limitations. |
| Understand the models and simulations associated with requirements generation, program management, design and engineering, manufacturing, T&E, logistics support and training. |
| Identify and assess the M&S requirements, benefits, pitfalls, planning and applications in systems acquisition. |
| Understand system dynamics, discrete event models, discrete multi-variate modeling. |
| Prototyping |
| Understand the role of prototyping in spiral development. |
| Incorporate early prototyping. |
| Manage experimentation and prototyping. |
| Robust Engineering |
| Respond quickly and effectively to changing conditions or events that impact the program's SE processes. |
| In initial stages of product development, instill flexibility in both resources provided and the product's performance requirements to allow for the uncertainties of technical progress. |
| In initial stages of product development, instill high standards for technical maturity. |
| Understand and use robust design techniques and tools for the system. |
| Ensure process variability reduction implementation. |
| Modular Open System Design |
| Employ modular design. |
| Designate key interfaces. |
| Design for affordable change. |
| Develop an integrated roadmap for design and development. |
| Use open standards. |
| Assess feasibility of using widely-supported standards. |
| Test and Evaluation Master Plan |

| SYS 101--The Systems Engineering Processes |
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| Understand the Test & Evaluation Master Plan (TEMP), and other related documents and their relationship to the SEP and the acquisition process. |
| Coordinate in the development of the TEMP. |
| Technical Data Packages |
| Prepare technical data packages. |
| Determine the purpose and timing of technical data packages and other system specific information over the lifecycle. |
| Specifications |
| Determine the purpose and timing of specifications over the lifecycle. |
| Recognize the content and format of a specification. |
| Employ templates for performance specifications; include examples such as those contained in the JACG's series of specification guides. |
| Earned Value Management |
| Understand Earned Value (EV) principles, evaluate EV data, and make recommendations. |
| Recognize the value and benefits of EVM in the acquisition process. |
| Analyze the contractor's status by applying EV analysis techniques. |
| Ensure that contractors have an EVM system that reports cost and schedule information at a level of work that provides information specific to software development. |
| Technical Reviews |
| Understand how the Program Manager (PM) and SE staff should prepare for and follow up on technical reviews. |
| Understand how each configuration baseline and applicable specifications relate to specific technical reviews. |
| Develop plans for technical reviews throughout the life cycle. |
| Identify the level/type of the review. |
| Understand the role of technical reviews as another means of controlling technical risk and providing performance-based progress measurement. |
| Establish exit/entry criteria and do not close a technical review until all established exit criteria are met. |

| SYS 101--The Systems Engineering Processes |
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| Recognize the purpose of technical reviews as a means of controlling technical risk and assessing design maturity.<br><br>Differentiate how each configuration baseline corresponds to an applicable program-unique specification(s) and a specific technical review. |

## SPRDE/SE DUTIES AND TASKS—SYS 201

These duties and tasks are divided by shaded headings. The major headings are highlighted in dark gray: IPPD, Acquisition, Technical Reviews, and SE by Phases. The sub-headings are shown in lighter gray.

| **SYS 201--Systems Engineering by Acquisition Phase** |
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| Assess key policies, laws, and regulations; support issues; development paradigms and strategies that characterize the current DoD acquisition environment. |
| IPPD |
| Understand the implementation, barriers, organization structure, etc. of the IPPD/IPT concept. |
| Select organization and teaming techniques, i.e. IPT structure. |
| Encourage early and strong government/industry SE activity prior to the forming and chartering of specific IPTs. |
| Designate as IPTs only those teams that will have the day-to-day responsibility for developing and delivering a product and the expertise to do so. |
| Assign responsibilities for ESOH management and establish ESOH IPTs/working groups. |
| Recognize the nature of group interaction, its principle phases, and how teams arrive at better solutions. |
| Apply the IPPD principles within the SE processes as performed by IPTs. |
| Identify the key IPPD concepts and implementation strategies. |
| Associate the following IPT concepts with their definitions: IPT Principles; IPT roles and responsibilities; IPT organizational structure; team dynamics and government's role; team metrics; team size; team leader; IPT charter; IPPD tools. |
| Distinguish SE from IPPD. |
| Develop and implement an organizational structure where SE spans the entire organization, rather than separating SE into a specific IPT. |
| Prepare budgets for SE IPTs.. |
| Identify ESOH resource requirements. |
| Evaluate organization, communication and teaming techniques that facilitate IPPD. |
| Understand the role of government oversight when participating on contractor's IPTs. |
| Acquisition |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Assess the interaction of SPRDE with the CJCS 3170.01 JCIDS process, the DoD Planning, Programming, Budgeting and Execution (PPBE) process, and the DoD 5000 series acquisition life cycle process. |
| Operate in a multi-service environment. |
| Apply the appropriate defense acquisition policies and SE processes necessary for successful execution of phase activities. |
| Recognize the need for a phased acquisition approach and a tailored acquisition strategy. |
| Understand roles/responsibilities of acquisition stakeholders. |
| Evolutionary Acquisition |
| Develop EA design strategies and ensure the system design supports the EA approach. |
| Match evolutionary requirements with capability needs. |
| Use evolutionary acquisition and spiral development as a framework for system and software development programs. |
| Establish requirements early in the program to accomplish technology refresh to preclude obsolescence early in the program and include the topic throughout the development process. |
| Perform the expectancy analyses for parts susceptible to early obsolescence as part of the SE processes very early in the development cycle and include design considerations that facilitate technology refresh. |
| Use the SE processes to balance program risk, system performance, and cost over the lifecycle of a system incorporating an evolutionary acquisition approach. |
| Establish program plans to accommodate requirements changes that exceed the program baseline by deferring them to future upgrades, modifications, or increments. |
| Address requirements identified subsequent to the System Requirements Review (SRR) in future upgrades. |
| Technical Reviews |
| Understand the objective of specific major technical reviews, issues to be addressed in each, and their relationship to the acquisition life cycle. |
| Associate the types of major reviews with the issues to be addressed in each, and each review’s relationship to the acquisition life cycle. |
| Conduct technical reviews to provide the PM with an integrated assessment of program technical risk and readiness to proceed to the next technical phase of effort. |
| Form a team of independent SME and program team representatives to perform technical reviews. |
| Appoint an independent technical authority to chair the technical review team. |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Include technical reviews in contractual documents. |
| Tailor the technical reviews in conjunction with the SE process to fit the acquisition program. |
| Approve technical baselines at technical reviews. |
| Conduct technical reviews using an event driven approach rather than by schedule. |
| Develop metrics for use in technical reviews. |
| Identify potential problems and propose solutions during technical reviews. |
| Develop and defend a checklist based on the most relevant event criteria for a specific technical review. |
| SE by Phases |
| Address SE upfront and early (all acquisition phases not just System Development and Demonstration (SDD). |
| Explain the interrelationships between different life cycle activities including prerequisite activities and cause and effect between phases. |
| Understand the inputs and outputs to each acquisition phase. |
| Understand the systems acquisition life cycle phases and the major activities to be accomplished in each phase. |
| Incorporate ESOH consideration throughout the system's life-cycle. |
| Emphasize life-cycle cost implications in all program management phases and decisions. |
| Quantify milestone requirements. |
| Prepare reports for milestone decision reviews. |
| Establish exit criteria to enter subsequent phase. |
| Solicitation and Source Selection |
| Require in section L of the solicitation, an SE process description tailored to the program as part of the proposal. This could be in a contractor format, but must address the SE processes as they will be applied to the program. |
| Explain how the SOW and RFP are evaluated from an SE perspective. |
| Develop performance-based work statements or statements of objectives (SOO). |
| Contrast the purpose, preparation, and evaluation strategies of the SOO with those of the SOW. |
| Prepare a SOW and be able to critique the structure and content of one. |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Recognize how the acquisition excellence and source demands impact solicitation development. |
| Recognize the interrelationships between the acquisition management systems data list (AMSDL), the CDRL, and the DID. |
| Recognize how evaluation factors in the RFP are utilized during the source selection process to identify SE requirements. |
| Identify the ESOH considerations that should be included in the RFP, SOO, and SOW. |
| Require proposed reuse to be fully supported in the proposals and consider risks in the evaluation. The proposal solicitation should include a reuse checklist to address the soundness of the proposed reuse candidates and approach, confirm reuse compliance with requirements, quantify the attendant risk, and require development of risk mitigation plans. |
| Establish a requirement in proposal solicitations for delivery of a preliminary specification tree and description of the SE processes that will be used to maintain the specifications and specification tree over the life of the program in the proposal. |
| Understand the basic ethical issues related to government employees and professional engineers in source selection. |
| Prepare technical aspects of the source selection plan. |
| Develop technical evaluation criteria for the technical proposal. |
| Evaluate technical proposals. |
| Nominate SE representatives to the Source Selection Evaluation Board. |
| Employ/develop sourcing strategies that emphasize best value. |
| Concept Refinement |
| Develop the various SE related inputs and outputs of the Concept Refinement phase. |
| Analyze what is achievable within the cost, schedule, and technical envelope. |
| Determine how the TEMP is used to integrate T&E planning activities in support of a program's acquisition strategy. |
| Understand the purpose of Advanced Technology Demonstrations. |
| Conduct market research. |
| Know and understand future technological advances that can be incorporated into system development programs. |
| Assess technology opportunities and evaluate the feasibility, maturity, and risk. |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Apply the science and technology base to solve military problems and create opportunities and options.<br><br>Evaluate the effective execution of the entire Concept Refinement phase using the SE processes.<br><br>Analyze technology opportunities and their impact on feasibility, maturity, safety, risk, affordability and utility tradeoffs to provide future military capabilities.<br><br>Perform Concept Refinement decomposition and definition activities.<br><br>    Interpret user needs; Analyze operational capabilities and define environmental constraints.<br><br>    Develop concept performance (and constraints) definition and verification objectives.<br><br>    Decompose concept performance into functional definition and verification objectives.<br><br>    Decompose concept functional definition into component concepts and assessment objectives.<br><br>    Develop component concepts, including enabling/critical technologies; Update constraints and cost/risk drivers.<br><br>Perform Concept Refinement integration and verification/validation activities.<br><br>Perform requirements validation.<br><br>    Assess/analyze enabling/critical components versus capabilities.<br><br>    Assess/analyze concept system versus functional capabilities.<br><br>    Assess/analyze concept and verify the system concept's performance.<br><br>    Analyze and assess concepts versus defined user needs and specified environmental constraints.<br><br>Prepare products/outputs of the SE process in Concept Refinement.<br><br>    Conduct AoA.<br><br>    Develop a Technology Development Strategy (TDS).<br><br>    Develop a SEP.<br><br>    Choose a Preferred System Concept (PSC).<br><br>    Consider technology issues.<br><br>    Develop a T&E strategy.<br><br>    Create exit criteria.<br><br>    Conduct economic analysis (Major Automated Information System (MAIS) only). |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Conduct Concept Refinement technical reviews. |
| Prepare for and conduct Initial Technical Review (ITR). |
| Prepare for and conduct Alternative System Review (ASR). |
| Identify the ESOH considerations that should be included in the ICD. |
| Technology Development |
| Develop the various SE related inputs and outputs of the Technology Development phase. |
| Include basic SE on programs that have substantial requirements definition and top level efforts prior to milestone B, e.g., during Technology Development. Complete the system level requirements and design per defined criteria prior to Milestone (MS) B if appropriate. |
| Recognize the state of U.S. technology, the role and planned evolution of science and technology, and how these two elements apply to the different phases of defense acquisition. |
| Understand technology transfer, transition, and insertion. |
| Construct the technology development cycle; describe the purpose of each phase of the cycle, and explain how it relates to the acquisition life cycle. |
| Determine which phase in the technology development cycle is involved when inserting technology. |
| Recognize how technology development programs mature across the technology development cycle. |
| Understand the effects technology has on the following: manufacturing technology; industrial capabilities; technology support; and non-developmental items and commercial items. |
| Recognize the role of an open systems approach within technology development and insertion. |
| Understand current state-of-the-art and mechanisms to introduce technology. |
| Conduct market research. |
| Accurately assess and understand the risks associated with current technology maturity in relation to program needs. |
| Assess technological opportunities and evaluate the feasibility, maturity and risk. |
| Evaluate technology maturation to support short cycle time in system development. |
| Evaluate the effective execution of the entire Technology Development phase using the SE processes. |
| Determine the technical management activities that must be completed prior to transitioning a program into system acquisition. |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Perform Technology Development decomposition and definition activities.<br><br>Interpret user needs; Analyze operational capabilities and define environmental constraints.<br><br>Develop system performance (and constraints) specifications and enabling/critical technologies and verification objectives.<br><br>Develop functional definitions for enabling/critical technologies and associated verification plan.<br><br>Decompose functional definitions into critical component definition and technology verification plan.<br><br>Develop system concepts, including enabling/critical technologies. Update constraints and cost/risk drivers.<br><br>Perform Technology Development integration and verification/validation activities.<br><br>Demonstrate enabling/critical technology components versus planned technology components.<br><br>Demonstrate system functionality versus planed functionality.<br><br>Demonstrate/model the integrated system versus the performance specification.<br><br>Demonstrate and validate the system concepts and technology maturity versus defined user needs.<br><br>Prepare products/outputs of the SE processes in Technology Development.<br><br>Continue conducting AoA.<br><br>Continue development of TDS.<br><br>Develop Product Support Strategy.<br><br>Provide technical support to development of CDD.<br><br>Create technical exit criteria.<br><br>Conduct technology readiness assessment.<br><br>Conduct independent technology assessment.<br><br>Develop C4I support plan.<br><br>Conduct system threat assessment.<br><br>Provide technical input to refined acquisition strategy.<br><br>Develop TEMP.<br><br>Prepare Live-Fire T&E (LFT&E) waiver request and alternative LFT&E plan. |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Compile operational test agency report of OT&E results. |
| Develop program protection plan. |
| Adhere to Clinger-Cohen Act Compliance (MAIS and other IT systems including National Security Systems). |
| Prepare Programmatic ESOH Evaluation. |
| Identify Low Rate Initial Production (LRIP) quantities. |
| Develop independent cost estimate and manpower estimate. |
| Create affordability assessment. |
| Conduct component cost analysis. |
| Create CARD. |
| Create unit cost report. |
| Reassess EVM system. |
| Develop Acquisition Program Baseline (APB). |
| Prepare Selected Acquisition Report (SAR). |
| Adhere to spectrum certification compliance. |
| Conduct registration of mission-critical and mission-essential information systems. |
| Conduct technical reviews during Technology Development. |
| Prepare for, conduct and take corrective actions resulting from SRR. |
| Prepare for, conduct and take corrective actions resulting from Integrated Baseline Review (IBR). |
| Prepare for, conduct and take corrective actions resulting from technology readiness assessment. |
| System Development and Demonstration |
| Develop the functional, allocated, and product baselines. |
| Develop the various SE related inputs and outputs of the SDD phase. |
| Conduct tests (development test, operational test, contractor, live fire, acceptance, etc.). |
| Integrate with test activities. |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Assist in test planning and design.<br><br>Respond to issues arising during test.<br><br>Analyze test results.<br><br>Evaluate the SE product and processes used during SDD.<br><br>Perform key SE activities during System Integration.<br><br>Interpret user capability needs. Refine system performance specifications and environmental constraints.<br><br>Develop system functional specifications and system verification plan.<br><br>Evolve functional performance specifications into Configuration Item (CI) functional (“design to”) specifications and CI verification plan.<br><br>Evolve CI functional specifications into product (“build to”) documentation and inspection plan.<br><br>Fabricate, assemble, code to “build to” documentation.<br><br>Conduct technical reviews during System Integration.<br><br>Prepare for, conduct and take corrective actions resulting from IBR.<br><br>Prepare for, conduct and take corrective actions resulting from SRR.<br><br>Complete definition of verification requirements should be an integral part of writing specifications and be part of the exit criteria for the formal specification review, e.g., SRR and software specification review.<br><br>Require all test requirements be identified in specifications by the SRR.<br><br>Employ IMP criteria for the SRR and system level design review events to assure completeness.<br><br>Prepare for, conduct and take corrective actions resulting from System Functional Review (SFR).<br><br>Prepare for, conduct and take corrective actions resulting from PDR.<br><br>Require all test plans be in place to satisfy the requirements by the PDR.<br><br>Prepare for, conduct and take corrective actions resulting from Critical Design Review (CDR).<br><br>Require a full comprehensive integration and test plan as entrance criteria for CDR.<br><br>Perform key SE activities during System Demonstration. |

| SYS 201--Systems Engineering by Acquisition Phase |
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| Conduct individual CI verification DT&E. |
| Conduct system and integration DT&Es and Operational Assessments (OAs). Verify system functionality and constraints compliance to specifications. |
| Perform combined DT&E/OT&E. Demonstrate system to specified user needs and environmental constraints. |
| Conduct technical reviews during System Demonstration. |
| Prepare for, conduct and take corrective actions resulting from Test Readiness Review (TRR). |
| Prepare for, conduct and take corrective actions resulting from Flight Readiness Review. |
| Prepare for, conduct and take corrective actions resulting from System Verification Review (SVR). |
| Prepare for, conduct and take corrective actions resulting from Production Readiness Review (PRR). |
| Prepare for, conduct and take corrective actions resulting from technology readiness assessment. |
| Prepare products/outputs of the SE process in System Demonstration. |
| Update documents from MS B. |
| Provide technical support to the development of the CPD. |
| Production and Deployment |
| Develop the various SE related inputs and outputs of the Production and Deployment phase. |
| Evaluate manufacturing/production planning scheduling/control systems. |
| Understand the impact of production rates on contractor manning processes. |
| Evaluate production rate capability. |
| Conduct learning curve evaluation. |
| Analyze impact of second source/split buy/competitive production contract. |
| Determine the role of OT&E in the acquisition life cycle. |
| Use SE processes to monitor and control the system configuration, support the production process, and control the program cost and schedule. |
| Identify the ESOH considerations that should be included in the CPD. |
| Perform key SE activities during LRIP. |

| SYS 201--Systems Engineering by Acquisition Phase |
|---|
| Analyze deficiencies to determine corrective actions. |
| Modify configuration (hardware, software, and specifications) as necessary to correct deficiencies. |
| Verify and validate production configuration. |
| Prepare products/outputs of the SE process in LRIP. |
| Conduct Full Rate Production Decision Review. |
| Update documents from MS C. |
| Compile beyond-LRIP report. |
| Develop LFT&E report. |
| Prepare component LFT&E report. |
| Obtain C4I supportability certification. |
| Obtain interoperability certification. |
| Conduct post-deployment performance review. |
| Conduct technical reviews during LRIP. |
| Prepare for, conduct and take corrective actions resulting from IBR. |
| Prepare for, conduct and take corrective actions resulting from Operational Test Readiness Review (OTRR). |
| Prepare for, conduct and take corrective actions resulting from Physical Configuration Review (PCR). |
| Conduct technical reviews during full rate production and deployment. |
| Prepare for, conduct and take corrective actions resulting from IBR. |
| Prepare for, conduct and take corrective actions resulting from PCR. |
| Operations and Support Phase |
| Develop the various SE related inputs and outputs of the Operations and Support phase. |
| Monitor experienced system performance and failures, identify root causes, evaluate risks, and provide the program manager with an integrated technical assessment of system trends, corrective action alternatives, staffing and resource requirements. |
| Understand the role of SE in product improvements during development and the post-production operations and support phases. |

**SYS 201--Systems Engineering by Acquisition Phase**

Identify any problems that may exist in a product improvement scenario and how the SE processes are used to avoid such problems.

> Understand that product improvement is implemented within the SE processes.

> Understand product improvements for legacy systems under an open systems approach.

Identify improvements to systems for the purpose of Operations and Support cost reduction, safety, replacing obsolete parts, reliability, tech insertion, etc.

> Use SE processes to implement these changes.

Evaluate use of the SE processes to reduce risk of operational/support problems.

Understand the impact of design on the operations and test environment.

Identify sources and methodologies for technology insertions.

> Understand commercial and military state of the art technology applications.

> Know and understand open architecture discipline, tools, methods to improve aging systems/platforms O&S (specifically for tech insertions).

> Know methodologies for inserting technology upgrades and maintaining technical currency.

Take practical courses of action to achieve improved performance, cost or safety in weapon systems by modifying existing systems and taking advantage of the methodologies which permit achieving successful modification.

Perform key SE activities during Sustainment.

> Monitor and collect all service use data.

> Analyze data to determine root cause of problem.

> Determine the risk/hazard severity of the system.

> Develop corrective action.

> Integrate and test corrective action.

> Assess risk of improvements.

> Implement and field systems.

Prepare products/outputs of the SE process in Sustainment.

> Create modifications to fielded systems.

> Provide technical support for the updated CDD for next spiral increment (if applicable).

| SYS 201--Systems Engineering by Acquisition Phase |
|---|
| Compile data for Industrial Security Regulation ( ISR). |
| Conduct technical reviews during Sustainment. |
| Prepare for, conduct and take corrective actions resulting from in-service review. |
| Disposal |
| Prepare a demilitarization and disposal plan. |

## SPRDE/SE DUTIES AND TASKS—SYS 301

These duties and tasks are divided by shaded headings. The major headings are highlighted in dark gray: Total Systems View, Organization, Technical Basis for Cost, Contract Technical Management, Financial Management, International Acquisition, Professional Ethics and Leadership. There are no sub-headings in this list.

| **SYS 301--SE Management and Leadership** |
|---|
| Evaluate technical issues, assess program performance, make recommendations, and effectively present these issues to diverse audiences. |
| Build, work in, motivate, and lead high-performing multidisciplinary teams. |
| Total Systems View |
| Think beyond engineering and consider all functions and stakeholders in the SE processes. |
| Understand the entire acquisition process. |
| Organization |
| Explain the barriers, enablers, organization structure, etc. for implementing SE. |
| Understand the roles and responsibilities across the system life cycle. |
| Maintain a robust SE organization. |
| Respond to program manager and functional SE leadership regarding the proper application of SE to meet program objectives. |
| Assign a lead systems engineer at program inception to be responsible for the proper application of SE to meet program objectives. |
| Staff the organic SE team commensurate with the scope of the system, sophistication/experience of the contractors, and integration challenge of the system. |
| Operate as lead engineer, responding directly to program manager. |
| Require creation of a single technical authority that is responsible for the overall technical effort and empowered to resolve technical issues. This position should be established both in the government program office and the contractor program office. This technical authority should report to the Program Director. |
| Assess and improve SE processes. |
| Technical Basis for Cost |
| Analyze how the implementation of cost containment in an acquisition program supports the Cost As an Independent Variable (CAIV) philosophy. |
| Differentiate the effects the CAIV strategy has on the cost containment efforts (e.g., Total Ownership Cost (TOC), Design-To-Cost (DTC), risk management, competition, open systems, and value management. |
| Recognize the composition and role of the cost performance-integrated product team within the acquisition life cycle. |

| SYS 301--SE Management and Leadership |
|---|
| Distinguish cost objectives for the following: Research, Development, Test and Evaluation (RDT&E); procurement; military construction; production; operational support: disposal; indirect costs; and infrastructure tests.<br><br>Recognize how contractor incentives influence reaching or exceeding cost objectives.<br><br>Select metrics to track and monitor progress to objectives.<br><br>Implement operational cost reduction.<br><br>Know and understand components of the Reduction of Total Ownership Cost (RTOC) methodology.<br><br>Assess design impact on total operational cost and identify means to reduce TOC.<br><br>Understand designing for change using techniques such as open systems architectures.<br><br>Understand CAIV.<br><br>Evaluate the system's technical basis for cost.<br><br>Document the percentage of total funding to be spent on organic and outsourced SE efforts in system contracts.<br><br>Examine planned programmed resources to ascertain if adequate resources are budgeted to execute the proposed SE processes.<br><br>Understand why and when technical cost estimates are needed.<br><br>Identify cost structure of the various technical cost estimates.<br><br>Perform independent technical cost estimates/analyses.<br><br>Consider/identify life cycle costs.<br><br>Identify technical cost estimating methods.<br><br>Be able to do parametric analyses with respect to affordability assessments/analyses.<br><br>Apply appropriate technical cost estimation method(s) for each of the program phases.<br><br>Know and understand affordability assessment techniques and tools.<br><br>Develop and defend program engineering requirements and cost estimates with user support.<br><br>Understand operating and support cost data and data sources and their differences.<br><br>Understand cost estimation tools/models and their limitations. |
| Contract Technical Management |
| Understand contractors' SE processes and perspectives.<br><br>Require contractors to address how the SE processes will be applied to all system and subsystem development on the program in their proposal, including how they will be applied to those subsystems that are subcontracted. These SE processes must be described in the proposal, and after contract award, published in a program document available to all program participants and stakeholders. Prime contractors should be required to flow down a requirement for defined, written SE processes to their development subcontractors. |

| SYS 301--SE Management and Leadership |
|---|
| Contracts with the primes should be structured to require technical engineering management visibility and status reporting (metrics) of major development activities at the subcontractor level and should be included in the prime contractor's reporting.<br><br>Work with contractors and provide informed assessments of their progress.<br><br>Certify technical progress.<br><br>Develop contract documents.<br><br>Document the requirements for the SE processes by phase in system contracts.<br><br>Distinguish responsibilities of contracting officer vs. engineer, including contracting officer's technical representative.<br><br>Capitalize on opportunities to develop performance based solicitations for systems.<br><br>Develop performance expectations, incentives and metrics to describe acquisition needs and evaluate outcomes. |
| Financial Management |
| Understand the Planning, Programming, Budgeting, and Execution System (PPBES) sources and uses of funds, and how budget issues impact the program.<br><br>Manage budget effects on the technical program. |
| International Acquisition |
| Understand International Acquisition (IA) policy and techniques.<br><br>Utilize offshore technology in system design where it provides a benefit.<br><br>Assess security impacts of international acquisition.<br><br>Assess ESOH impacts of international acquisitions.<br><br>Assess releasability of candidate technologies.<br><br>Ensure standardization, interoperability.<br><br>Identify the benefits and pitfalls in international acquisition from a SPRDE manager's perspective. |
| Professional Ethics |
| Employ professional ethics.<br><br>Differentiate judgments, legal issues, and ethical issues.<br><br>Evaluate ethical issues in engineering and business practices. |
| Leadership |
| Plan and know your leadership objectives.<br><br>Provide resources for workers (e.g., money, people, and facilities.<br><br>Reward and discipline appropriately. |

| SYS 301--SE Management and Leadership |
| --- |
| Act as "mentor" for leaders of tomorrow.<br><br>Foster technical training and education.<br><br>Develop a plan for professional SE training and development.<br><br>Train the program participants in the execution of SE processes, including the value of the processes and the importance of applying the SE processes.<br><br>Establish a program and process for incentivizing career SE positions within the government.<br><br>Promote technical career development and growth. |

# Appendix L
# SPRDE/SE Performance Objectives (POs)

## SPRDE/SE PERFORMANCE OBJECTIVES

| SPRDE/SE Performance Objectives |
|---|
| *Key: Dark gray high level topic; Light gray subtopics* |
| Total Systems View-- |
| Articulate the value of systems engineering in the acquisition process |
| Acquisition |
| Apply the appropriate Defense acquisition policies and SE processes necessary for successful execution of phase activities |
| Evolutionary Acquisition (EA) |
| Match evolutionary requirements with capability needs |
| IPPD |
| Apply the IPPD principles within the SE processes as performed by Integrated Product Teams (IPTs) |
| Leadership |
| Evaluate leadership of contractor and government technical/management IPTs |
| Organization |
| Explain how to implement and sustain a robust systems engineering organization. |
| Financial Management |
| Understand the Planning, Programming, Budgeting, and Execution System (PPBES) sources and uses of funds, and how budget issues impact the program. |
| Contract Technical Management |
| Evaluate contractors' SE processes and perspectives in proposals |
| Technical Basis for Cost |
| Evaluate the system's technical basis for cost. |
| International Acquisition (IA) |

| SPRDE/SE Performance Objectives |
|---|
| Identify the benefits and pitfalls in international acquisition from a SPRDE manager's perspective |
| Professional Ethics |
| Evaluate ethical issues in engineering and business practices |
| SE Processes |
| Apply the systems engineering processes to transform requirements and constraints into an operational system design |
| Requirements Development |
| Develop a set of functional, physical, and operational requirement viewpoints in accordance with SE standards. |
| Requirements Management |
| Implement a disciplined requirements management process from the JCIDS outputs. |
| Architectural Design |
| Understand the evolution of the architecture from the established system requirements. |
| Design Solution |
| Translate outputs of the Architectural Design process into system product and process designs which duly consider life cycle issues. |
| Implementation |
| Understand the purpose, inputs and outputs of the Implementation process |
| Integration |
| Understand the purpose, inputs and outputs of the Integration process |
| Reinforce the importance of specifying, allocating, and controlling interface requirements including interfaces among the members of a SoS/FoS. |
| Verification |
| Apply the Verification process in order to ensure the system elements meet or exceed their requirements. |

| SPRDE/SE Performance Objectives |
| --- |
| Validation |
| Understand the purpose, inputs and outputs of the Validation process |
| Transition |
| Understand the purpose, inputs and outputs of the Transition process |
| Technical Planning |
| Differentiate the role of technical planning within the systems engineering effort from overall program planning |
| Technical Assessment |
| Assess programs and identify risks and pitfalls |
| Decision Analysis |
| Apply quantitative and qualitative tools to support problem solving and decision making in an acquisition environment |
| Risk Management |
| Apply the risk management process within an IPPD environment in order to determine program technical risk. |
| Configuration Management |
| Understand the configuration baselines (functional, allocated, and product ), when they are established, and why they are important. |
| Data Management |
| Contrast the roles and relationships of configuration management (CM), data management, and interface management. |
| Interface Management |
| Differentiate the following interface management function elements: Interface control working groups (ICWG) and interface control documentation (ICD). |
| SE by Phases |
| Understand the systems acquisition life cycle phases and the major SE activities to be accomplished in each phase |

| SPRDE/SE Performance Objectives |
|---|
| Solicitation and Source Selection |
| Explain how the SOW and RFP are evaluated from an SE perspective |
| Concept Refinement |
| Develop the various SE related inputs and outputs of the Concept Refinement phase |
| Technology Development |
| Develop the various SE related inputs and outputs of the Technology Development phase |
| System Development and Demonstration |
| Develop the various SE related inputs and outputs of the SDD phase |
| Production and Deployment |
| Develop the various SE related inputs and outputs of the Production and Deployment phase |
| Use the SE processes to monitor and control the system configuration, support the production process, and control the program cost and schedule |
| Operations and Support Phase |
| Develop the various SE related inputs and outputs of the Operations and Support phase |
| Evaluate use of the SE processes to reduce risk of operational/support problems |
| Disposal |
| SE Techniques and Tools |
| Understand and be able to use SE tools and methods |
| SEP |
| Develop/coordinate and implement the SEP |
| WBS |
| Recognize/Understand the Work Breakdown Structure (WBS) and its application throughout the systems engineering processes |
| Value Engineering |

| **SPRDE/SE Performance Objectives** |
|---|
| Understand value engineering methods and tools |
| Technical Performance Measurement |
| Determine the role of technical performance measurements (TPMs) in the systems engineering processes |
| Trade Studies |
| Understand the key alternatives or tradeoffs made as the system evolves through its life cycle from the conceptual level of development to the detailed subsystem level of development. |
| Modeling and Simulation |
| Identify and assess the M&S requirements, benefits, pitfalls, planning and applications in systems acquisition |
| Prototyping |
| Understand the role of prototyping in spiral development |
| Robust Engineering |
| Understand robust design techniques and tools |
| Modular Open Systems Architecture |
| Understand the Modular Open Systems Architecture technique |
| TEMP |
| Understand the Test & Evaluation Master Plan (TEMP), and other related documents and their relationship to the SEP and the acquisition process. |
| Technical Data Packages |
| Understand the purpose and timing of technical data packages and other system specific information over the lifecycle |
| Specifications |
| Understand the role of specifications over the lifecycle |
| Earned Value Management |
| Understand Earned Value (EV) principles, evaluate EV data, and make recommendations |

| SPRDE/SE Performance Objectives |
|---|
| Technical Reviews |
| Associate the types of major reviews with the issues to be addressed in each, and each review's relationship to the acquisition life cycle. |
| Design Considerations |
| Open Systems Architecture |
| Understand open systems architectures, disciplines, tools and methods and application to system interoperability |
| Architectures and Interoperability |
| Determine the purpose and timing of architectures over the life cycle |
| Software |
| Recognize the complexity of software development, its integral nature to the Systems Engineering processes, and top-level "best practices" for successful software development |
| COTS and NDI |
| Conduct SE analyses of the reuse and COTS candidates to determine that the candidates exist in acceptable usable form, that they meet the new system requirements, and that they are well documented and designed for reuse. |
| Manufacturing Capability and Producibility |
| Recognize the major producibility goals of the design effort and the DoD quality process which translates a released design to a producible product |
| Determine the role of manufacturing capability in the systems engineering process throughout the acquisition life cycle |
| Quality Assurance |
| Awareness of system quality methods? |
| Reliability, Availability and Maintainability |
| Identify the impact of reliability, availability, maintainability on system support and total ownership costs |
| Human Systems Integration |

| SPRDE/SE Performance Objectives |
| --- |
| Understand human and cognitive factors and their affect on the system technical effort |
| ESOH |
| Understand ESOH Statutes, Regulations, Policies, International Agreements, and Government/Industry Standards and how they affect Systems Acquisition Programs through the Life-cycle |
| Understand how to Integrate ESOH Considerations into the SE processes |
| Survivability |
| Develop survivability requirements |
| Corrosion Prevention and Control |
| Understand how corrosion prevention and control planning impacts system requirements |
| Disposal and Demilitarization |
| Understand the goals and objectives of disposal and demilitarization and their impact on the SE processes during the development of a weapon system |
| Information Assurance |
| Incorporate information assurance requirements into system design activities to ensure availability, integrity, confidentiality, authentication and non-repudiation of critical system information |
| System Security |
| Understand how system security engineering impacts system requirements |
| Test and Evaluation |
| Determine the role of test and evaluation (T&E) in the SE and acquisition management processes |
| Sustainment |
| Include sustainment as a topic throughout the design process; include sustainment specialists in program planning activities. |
| Determine how acquisition logistics activities impact and relate with SE and other functional areas within the acquisition life cycle |

# Appendix M
# SPRDE/SE Learning Outcomes (LOs)

# LEARNING OUTCOMES

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **Acquisition** | | | |
| **1** | Recognize SE best practice and processes. | Evaluate SE best practice and processes. | Compare SE best practice and processes. |
| **2** | | Structure SE processes to phase objectives and phase products (including in-service systems engineering). | Structure SE processes to phase objectives and phase products (including in-service systems engineering). |
| **3** | | Distinguish the relationship of program technical performance objectives to program budgets to program schedule as well as the methods required to assess the technical risks driving cost/schedule/performance risk. | Evaluate the relationship of program technical performance objectives to program budgets to program schedule as well as the methods required to assess the technical risks driving cost/schedule/performance risk. |
| **4** | | Determine the universe of performance requirements and constraints (technical and programmatic) that must be addressed and managed in the phase. | Derive the universe of performance requirements and constraints (technical and programmatic) that must be addressed and managed in the phase. |
| **Evolutionary Acquisition (EA)** | | | |
| **5** | | Analyze how evolutionary acquisition (e.g. incremental development) can be implemented in SE to achieve program objectives. | Assess how evolutionary acquisition (e.g. incremental development) can be implemented in SE to achieve program objectives. |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **6** | | Determine how incremental development/spiral development affects the technical aspects of the acquisition strategy as well as how they affect the technical nature of the SE phase products. | Evaluate how incremental development/spiral development affects the technical aspects of the acquisition strategy as well as how they affect the technical nature of the SE phase products. |
| **7** | | Examine technical risk as a major determinant of planned evolutionary approaches. | Evaluate technical risk as a major determinant of planned evolutionary approaches. |
| **8** | | Relate the quality of the phase's technical products to the risk mitigation of follow-on phases. | Recommend the quality of the phase's technical products to the risk mitigation of follow-on phases. |
| **9** | | Determine the appropriate systems engineering efforts required to achieve acceptable levels of risk for entry into the next acquisition phase. | Critique the appropriate systems engineering efforts required to achieve acceptable levels of risk for entry into the next acquisition phase. |
| **10** | Identify the systems engineering efforts required in each acquisition phase. | Contrast the systems engineering efforts required of the acquisition phase to the acquisition products required of that phase. | Formulate the relationship of the systems engineering efforts required of the acquisition phase to the acquisition products required of that phase. |
| **11** | | Determine, based on program technical scope and risk, the level of systems engineering required and the subject matter expertise required to execute. | Evaluate, based on program technical scope and risk, the level of systems engineering required and the subject matter expertise required to execute. |
| **IPPD** | | | |
| **12** | | Apply IPPD principles to the conduct of SE as applied to an acquisition program. | Assess proper implementation of IPPD principles in conducting SE during an acquisition program. |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **13** | | Examine the implementation of IPPD on government IPTs and integrate the approach to the contractor's implementation of IPPD. | Recommend the implementation of IPPD on government IPTs and integrate the approach to the contractor's implementation of IPPD. |
| **14** | | Determine processes and products linkage on IPTs. | Assess processes and products linkage on IPTs. |
| **15** | | Structure program SE implementation to provide for cross-IPT controls of requirements and constraints budgets. | Assess program SE implementation for proper cross-IPT controls of requirements and constraints budgets. |
| **16** | | Recognize the subject matter expertise required on IPTs to implement IPPD across the full spectrum of requirements and design considerations. | Recommend the subject matter expertise required on IPTs to implement IPPD across the full spectrum of requirements and design considerations. |
| **17** | | | Justify IPPD tailored to acquisition phase, providing for required integration across the system, across IPTs, and across subject matter domains. |
| **Leadership** | | | |
| **18** | | | Arrange proper control and reporting mechanisms for leadership of the overall technical effort, for systems engineering, for requirements management, and for systems integration. |
| **19** | | | Evaluate process and product oversight mechanisms to ensure insight to technical risk at each technical phase of effort. |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **20** | | | Assess implementation of technical review chairmanship/leadership to include the application of technical review best practice (entry/exit criteria, evaluation of program/product technical maturity, determination of critical participants, and conduct of technical risk assessment against objective measures). |
| **Organization** | | | |
| **21** | | Determine how IPTs should be structured to meet technical objectives. | Determine how IPTs should be structured to meet technical objectives. |
| **22** | | | Determine how IPTs should be staffed to address technical scope and risk, systems development, systems integration, and full application of systems engineering. |
| **23** | | | Determine IPT staffing required to address allocated requirements and design constraints (budgets) using cross-functional teams. |
| **24** | | Apply cross-IPT mechanisms for functional and system integration. | Construct cross-IPT mechanisms for functional and system integration. |
| **25** | | Identify mechanisms for cross-IPT management of KPPs, critical operation requirements, critical budgets (weight, power, etc.). | Construct mechanisms for cross-IPT management of KPPs, critical operation requirements, critical budgets (weight, power, etc.). |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **Financial Management** | | | |
| **26** | | Recognize the technical aspects of a program and how these relate to the cost accounts set up in the Earned Value system. | Consider the technical aspects of a program and how these relate to the cost accounts set up in the Earned Value system. |
| **27** | | Recognize what types of technical effort need to be tracked as earned value to make the EVM system effective and importance of minimizing use of level-of-effort cost accounts. | Recognize what types of technical effort need to be tracked as earned value to make the EVM system effective and importance of minimizing use of level-of-effort cost accounts. |
| **28** | | | Use EVM data to track technical performance and use as a decision-making mechanism for resource re-allocation. |
| **29** | | | Assess technical adequacy of cost accounts versus technical risk, technical scope, and technical uncertainty. |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **Contract Technical Management** | | | |
| **30** | Recognize offerors' descriptions of key SE processes and practices as presented in proposals | | Evaluate the offeror's proposed approach in the area of SE to include: 1) the level of capability maturity in SE and other technical process areas, 2) the understanding of SE processes and standards to be used, 3) appropriateness of SE process application to the phase, 4) adequacy of technical baseline products as development control mechanisms, 5) technical reviews as integrated (program team and independent subject matter expert) technical assessment tied to objective entry/exit criteria, 6) independent technical chair for reviews, 7) subject matter expertise appropriate for the scope and risk of the program. |
| **31** | | | Determine contractual content required for proper application of SE to include incentives for SE performance (ensure that progress payments are not tied to technical review completion) and provisions for SE product and technical information availability. |
| **32** | | Identify pitfalls of tying progress payments to technical reviews completion. | |
| **33** | Understand the various types of contractor financing to include progress payments | Ensure that progress payments are not tied to technical review completion. Determine the best methods to finance contractor efforts | Assess the effectiveness of the various types of contractor financing options |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **34** | | Develop an SE surveillance plan | Assess contractor's SE performance |
| **35** | Define contractor system processes | Determine contractor's SE system processes | Predict contractor's SE performance |
| **36** | Recognize contractor SE standards and processes that are applied in each acquisition phase | Develop an SE surveillance plan based on those standards | Evaluate contractor's performance based on the phase of the program. |
| **37** | Describe the technical baseline products | Examine the relationships between the technical baseline products and the SE processes. | Evaluate contractor's performance based on the baseline products and SE processes |
| **38** | Define entry/exit criteria | Determine measures for entry/exit criteria | Integrate the entry/exit criteria measures into the SE performance plan |
| **39** | Understand purpose and content of technical reviews | Determine the different types of technical reviews during each phase of the acquisition process and the output of these reviews | Assess the contactor's performance based on the outcome of these technical reviews |
| **40** | Understand how SE staffing level change during each acquisition phase. Identify the tasks to be completed by the System engineer | Determine the appropriateness of the contractor's SE staffing levels. | Integrate the resourcing risk in to the SE performance plan |
| **41** | Identify the different types of contracts awarded to incentivize SE | Determine the appropriate level of SE incentive | Assess the effectiveness of putting SE incentives in contracts |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **42** | | Determine the types of technical information that should be contractually available for review | Evaluate contractor's performance based on technical information. |
| **43** | Define SE metrics | Determine appropriate SE metrics | Predict contractor performance based on product and process metrics |
| **44** | | | Explain how the SOW and RFP are evaluated from an SE perspective |
| **Technical Basis for Cost** | | | |
| **45** | | Identify cost drivers that affect the development of cost estimates and program budgets. | Apply knowledge of cost drivers to affect the development of cost estimates and program budgets. |
| **46** | | | Consider the effects of cost driver uncertainty on budget uncertainty and program risk. |
| **47** | | | Apply systems engineering best practice to define technical cost drivers on the program, commensurate with program phase requirements. |
| **48** | | | Construct the linkage of cost drivers to other aspects of the program (cost, schedule, performance) and articulate the relationships. |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **TOTAL SYSTEMS VIEW** | | | |
| **International Acquisition (IA)** | | | |
| **49** | | Identify the benefits and pitfalls in international acquisition from a SPRDE manager's perspective. | Assess the benefits and pitfalls in international acquisition from a SPRDE manager's perspective. |
| **Professional Ethics** | | | |
| **50** | Identify ethical issues in engineering and business practices | Assess ethical issues in engineering and business practices | Evaluate ethical issues in engineering and business practices. |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES ANDS TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE PROCESSES** | | | |
| | | | |
| **General** | | | |
| **51** | Recognize the national and international SE process standards in the conduct of SE in DoD acquisition | Distinguish SE process models in national and international SE process standards from life cycle models (waterfall, Vee, spiral) | Assess the national and international SE process standards in the conduct of SE in DoD acquisition |
| **52** | | | Revise and tailor the SE processes in the national and international SE process standards to an individual program |
| **TECHNICAL MANAGEMENT PROCESSES** | | | |
| **Decision Analyses** | | | |
| **53** | Describe the purpose, inputs and outputs of the Decision Analysis process | Apply the Decision Analysis process during each phase of an acquisition program | Evaluate group decision making and voting procedures in an IPPD environment on an acquisition program |
| **54** | | Apply quantitative and qualitative tools to support problem solving and decision making in an acquisition environment | |
| **55** | | Prepare documentation of decision rationale | |
| **Technical Planning** | | | |
| **56** | Describe the purpose, inputs and outputs of the Technical Planning process | Apply the Technical Planning process during each phase of an acquisition program | Assess contractor technical planning and/or execution efforts on an acquisition program |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES ANDS TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE PROCESSES** | | | |
| **57** | Explain the benefits of event criteria planning over calendar time-based scheduling | Apply control criteria and metrics to the Technical Planning process | |
| **58** | Recognize the role of technical planning with the SE effort from overall program planning | Categorize the sensitivity of interrelated tasks in the Systems Engineering Plan | |
| **Technical Assessment** | | | |
| **59** | Describe the purpose, inputs, and outputs of the Technical Assessment process | Apply the Technical Assessment process during all phases of an acquisition program | Assess an acquisition program to identify risks and pitfalls |
| **60** | | Use Measures of Performance and Effectiveness for proposed materiel solutions | Evaluate the contractor's technical management of their systems and processes (e.g. engineering, manufacturing, and quality) on an acquisition program |
| **Requirements Management** | | | |
| **61** | Describe the purpose, inputs, and outputs of the Requirements Management process | Apply the Requirements Management process during all phases of an acquisition program, e.g., from the ICD to the RFP performance requirements document, to contract specifications, to product specifications, etc. | Create plans to ensure that functional, design, performance, environment, cost and schedule requirements are being tracked |
| **62** | | Recognize the effective application of commercially available software tools to implement the requirements management and tracking process | For each baseline specification, develop program metrics to measure and track the extent of requirements changes in terms of number of requirements "shall statements" changed from contract award forward through the development cycle |

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| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE PROCESSES** | | | |
| **63** | | Relate lower level specifications to higher level requirements | Assess a contractor's implementation of requirements tracking tools and their capability in flowing down these tools to the subcontractor base to assure completeness on an acquisition program |
| **Risk Management** | | | |
| **64** | Describe the purpose, inputs and outputs of the Risk Management process | Apply the Risk Management process to an acquisition program within an IPPD environment in order to determine program technical risk and as a basis for making sound acquisition program decisions | Assess interrelationship of technical risk with cost and schedule |
| **65** | Describe how risk management is used to reduce operational and support problems | Apply risk management methodologies and tools | Develop risk management plans for prototyping, spiral development, evolutionary acquisition, modifications and upgrades |
| **66** | Summarize risk mitigation techniques (NDI, COTS, TAA, TAP) | Demonstrate early simulation demonstrations of reuse candidates in the risk management program as risk mitigation activities | Evaluate alternative approaches for moderate/high risks |
| **67** | Explain risk reporting system and tracking techniques | | |
| **Configuration Management** | | | |
| **68** | Describe the purpose, inputs, and outputs of the Configuration Management process | Apply the Configuration Management process during all phases of an acquisition program | Create the following configuration identification function elements: configuration items; configuration documentation; configuration baselines; and program-unique specifications |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES ANDS TOPICS | | | |
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| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE PROCESSES** | | | |
| **69** | Explain the configuration baselines (functional, allocated, and product) by when they are established and why they are important | Apply the following configuration control function elements: engineering change proposals (ECP); request for deviation (RFD); and configuration control boards | Plan baseline management including audits for a system in an acquisition program |
| **70** | Summarize the activities of a Configuration Control Board (CCB) | Analyze a change process in an acquisition program and track the engineering changes | Generate Configuration Baselines (functional, allocated, and product) at the appropriate time in the program |
| **71** | Summarize the technical support for developing Acquisition Program Baselines | | |
| **Technical Data Management** | | | |
| **72** | Describe the purpose, inputs, and outputs of the Technical Data Management process | Apply the Technical Data Management process during all phases of an acquisition program | Evaluate the quality of the technical data on an acquisition program |
| **73** | Define minimum essential life cycle technical data requirements | Trace technical data to requirements | Prepare technical data base in an integrated data environment |
| **Interface Management** | | | |
| **74** | Describe the purpose, inputs, and outputs of the Interface Management process | Apply the Interface Management process during all phases of an acquisition program | Evaluate the integrity of interface controls on an acquisition program |
| **75** | Explain the interface management process functions of the interface control working group (ICWG) and interface control documentation | Compare the roles of configuration management, technical data management, and interface management | Evaluate the treatment of the user's interoperability requirements for a system in an acquisition program |
| **76** | | Examine the relationships among configuration management, technical data management, and interface management | Create interface control documentation for a system in an acquisition program |

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|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE PROCESSES** | | | |
| **TECHNICAL PROCESSES** | | | |
| **Requirements Development** | | | |
| **77** | Describe the purpose, inputs, and outputs of the Requirements Development Process | Apply the Requirements Development process during all phases of an acquisition program | Develop requirements in an integrated framework |
| **78** | Identify all lifecycle stakeholders and the types of requirements from each | Analyze requirements flow down and allocation into specifications for a system in an acquisition program | Create derived system requirements expressed in terms of operational, functional, and physical viewpoints from the performance parameters in capability documents (ICD, CCD, CPD) |
| **79** | Describe lifecycle impacts and their relationship to requirements for a system in an acquisition program | Analyze behavioral requirements and design constraints for a system in an acquisition program | |
| **Logical Analysis** | | | |
| **80** | Describe the purpose, inputs and outputs of the Logical Solution process | Apply the Logical Solution process during all phases of an acquisition environment | Evaluate the preferred architecture for a system |
| **81** | Identify solution alternatives (training, doctrine, material, etc.) | Apply tools used in the Logical Solution process (functional flow block diagram, timeline sheets, and requirements allocation sheet) | Create a behavior model |
| **82** | Recognize functional analysis, functional allocation, and functional architecture activities | Demonstrate traceability from logical groupings (of functions, etc.) to requirements | Develop a functional architecture and the functional specifications for a system in an acquisition program |

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| **SE PROCESSES** | | | |
| **Design Solution** | | | |
| **83** | Describe the purpose, inputs and outputs of the Design Solution process | Apply the Design Solution process during all phases of an acquisition program | Generate the physical architecture for a system and allocate functions to physical elements |
| **84** | Describe how outputs of the Logical Solution process are translated into system product and process designs that duly consider life cycle issues | Analyze alternative design solutions and select one | |
| **85** | Recognize the proper completion of the top level system design and requirements allocation to subsystems prior to initiation of the subsystem design activity | Apply the tools and techniques of the Design Solution process (e.g., concept description sheets and schematic block diagrams) | Develop specification trees and specifications for a system in an acquisition program |
| **86** | Identify the role of industry standards in describing the physical architecture of a system | | |
| **87** | | Analyze outputs of modeling and simulation (M&S) activities during the Design Solution process | |
| **88** | | | Develop the M&S strategy and detailed approach for a system in an acquisition program. |
| **Implementation** | | | |
| **89** | Describe the purpose, inputs, and outputs of the Implementation process | Apply the Implementation process during each phase of an acquisition program | Develop documentation for system elements in an acquisition program |

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| **SE PROCESSES** | | | |
| **90** | Define the major variables and trends encountered in production and how they relate to other functional areas | Analyze the make/buy/reuse decisions for a system in an acquisition program | Develop the manufacturing strategy and manufacturing plan for a system in an acquisition program |
| **91** | Explain the activities in process inspection and product acceptance | Analyze a manufacturing system architecture | |
| **92** | Summarize acceptance testing activities | | |
| **Integration** | | | |
| **93** | Describe the purpose, inputs, and outputs of the Integration process | Apply the Integration process during each phase of an acquisition program | Evaluate impact of new system to current fielded solutions |
| **94** | Recognize system interfaces (Software/Software, Hardware/Software, Human) | Demonstrate the compatibility (or lack of) all functional and physical interfaces for a system in an acquisition program | Develop a system hardware and software integration plan for a system in an acquisition program |
| **95** | Describe system/subsystem interface requirements for a system in an acquisition program | Analyze the integration, testing, and modification of the physical product from lowest level through system level (test, analyze and fix) | Manage the definition/refinement of interfaces as the design matures for a system in an acquisition program |
| **96** | Explain the benefits of conducting system-level integration and test planning early in the program | | Evaluate the specification, allocation, and controlling of interface requirements of a system as a member of an SoS/FoS |
| **Verification** | | | |
| **97** | Describe the purpose, inputs, and outputs of the Verification process | Apply the Verification process during each phase of an acquisition program in order to ensure the system elements meet or exceed their requirements | Plan design solution verification for a system in an acquisition program |

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| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE PROCESSES** | | | |
| **98** | Explain how technical and operational performance is verified against established baseline in accordance with policy and legislation from component to system throughout the life cycle | Demonstrate that the proposed design solution meets requirements and is achievable within existing programmatic constraints | Create a verification requirement for each performance requirement "shall statement" and incorporate them into a narrative section four in the specification |
| **99** | Identify deficiencies that keep systems from meeting requirements | Distinguish between the systems verification planning process and mandatory test and evaluation planning requirements | |
| **100** | Explain how verification of interface requirements are captured in development and test plans | | |
| **Validation** | | | |
| **101** | Describe the purpose, inputs and outputs of the Validation process | Apply the Validation process during each phase of an acquisition program | Plan, develop, and evaluate tests throughout a system's acquisition life cycle, e.g., verification, validation, accreditation (VV&A), independent verification and validation (IV&V), metrics, technical performance measurement (TPM), and open systems (conformance testing) |
| **102** | | Demonstrate requirements, logical solution, and design solution validation | |
| **Transition** | | | |
| **103** | Describe the purpose, inputs and outputs of the Transition process | Apply the Transition process during each phase of an acquisition program | Plan the fielding process for a system in an acquisition program |
| **104** | Define transportation, packaging, handling, and storage requirements | Analyze a deployment system architecture | |

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| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **Overall** | | | |
| **105** | | Identify the programmatic value added by thorough application of SE processes. | Critique the programmatic value added by thorough application of SE processes. |
| **106** | | Prepare a SEP that describes the well thought out SE plan for individual acquisition programs. | Evaluate a SEP that describes the well thought out SE plan for individual acquisition programs. |
| **107** | | Conduct the analyses necessary for preparing the required statutory, regulatory, and contract reporting requirements in each acquisition phase. | Explain the analyses necessary for preparing the required statutory, regulatory, and contract reporting requirements in each acquisition phase. |
| **Concept Refinement (CR)** | | | |
| **108** | | Identify capability gaps and potential materiel solutions which should be supported by a robust analytical process incorporating innovative practices – including best commercial practices, collaborative environments, modeling and simulation and electronic business solutions. | Appraise capability gaps and potential materiel solutions which should be supported by a robust analytical process incorporating innovative practices – including best commercial practices, collaborative environments, modeling and simulation and electronic business solutions. |
| **109** | | Employ the systems engineering processes to conduct an Analysis of Alternatives for the selected concept. | Evaluate an Analysis of Alternatives for a selected concept from an SE perspective. |
| **110** | | Analyze the selected concept to arrive at a preferred solution, | |

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| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **111** | | Develop the Technology Development Strategy for a preferred solution. | |
| **112** | Describe user needs; operational capabilities and environmental constraints. | Interpret user needs; operational capabilities and environmental constraints. | Formulate user needs; operational capabilities and environmental constraints. |
| **113** | Define concept performance (and constraints) definition, and verification objectives. | Develop concept performance (and constraints) definition, and verification objectives. | Create concept performance (and constraints) definition, and verification objectives. |
| **114** | Explain how concept performance is decomposed into functional definition and verification objectives. | Show how concept performance is decomposed into functional definition and verification objectives. | Appraise the decomposition of concept performance into functional definition and verification objectives. |
| **115** | Explain how concept functional definition is decomposed into concept components and assessment objectives. | Show how concept functional definition is decomposed into concept components and assessment objectives. | Appraise the decomposition of concept functional definition into concept components and assessment objectives. |
| **116** | Identify component concepts, including enabling/critical technologies, constraints, and cost/risk drivers. | Examine component concepts, including enabling/critical technologies, constraints, and cost/risk drivers. | Assess component concepts, including enabling/critical technologies, constraints, and cost/risk drivers. |
| **117** | Differentiate enabling/critical components versus capabilities. | Analyze enabling critical components versus capabilities. | Assess enabling/critical components versus capabilities. |
| **118** | Differentiate the system concept versus functional capabilities. | Analyze system concept versus functional capabilities. | Assess system concept versus functional capabilities. |
| **119** | Describe the concept and the system concept's performance. | Analyze system concept's performance for the chosen concept. | Verify system concept's performance for the chosen concept. |

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| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **120** | Differentiate concepts versus defined user needs and specified environmental constraints. | Analyze concepts versus defined user needs and specified environmental constraints. | Assess concepts versus defined user needs and specified environmental constraints. |
| **121** | Recognize that the technical reviews normally conducted during CR include:<br>TR, which should provide:<br>(1) A complete CARD-like document detailing system overview, risk, system operational concept,<br>(2) An assessment of the technical and cost risks of the proposed Program, and<br>(3) An independent assessment of the Program's cost estimate | Identify that the technical reviews normally conducted during CR include:<br>TR, which should provide:<br>(1) A complete CARD-like document detailing system overview, risk, system operational concept,<br>(2) An assessment of the technical and cost risks of the proposed Program, and<br>(3) An independent assessment of the Program's cost estimate | Document that the technical reviews normally conducted during CR include:<br>TR, which should provide:<br>(1) A complete CARD-like document detailing system overview, risk, system operational concept,<br>(2) An assessment of the technical and cost risks of the proposed Program, and<br>(3) An independent assessment of the Program's cost estimate |
| **122** | Recognize that the technical reviews normally conducted during CR include:<br>ASR which should provide:<br>(1) An agreement on the preferred system concept(s) to take forward into Technology Development,<br>(2) Software architectural constraints/drivers to address Defense Information Infrastructure / Common Operating Environment (DII/COE) and system extensibility requirements, and<br>(3) An assessment of the full system | Identify that the technical reviews normally conducted during CR include:<br>ASR which should provide: (1) An agreement on the preferred system concept(s) to take forward into Technology Development,<br>(2) Software architectural constraints/drivers to address Defense Information Infrastructure / Common Operating Environment (DII/COE) and system extensibility requirements, and (3) An assessment of the full system software concept, and several other metrics. | Document that the technical reviews normally conducted during CR include:<br>ASR which should provide: (1) An agreement on the preferred system concept(s) to take forward into Technology Development,<br>(2) Software architectural constraints/drivers to address Defense Information Infrastructure / Common Operating Environment (DII/COE) and system extensibility requirements, and (3) An assessment of the full system software concept, and several other metrics. |

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| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| | software concept, and several other metrics. | | |
| **123** | | Identify that the outputs of CR include a preliminary system specification and a SEP. | |
| **Technology Development (TD)** | | | |
| **124** | | Identify that systems engineering processes are used in TD to develop a suite of technologies for the preferred system solution, once each required attribute is converted to a system performance specification. | |
| **125** | Describe user needs; operational capabilities and environmental constraints. | Interpret user needs; operational capabilities and environmental constraints. | Formulate user needs; operational capabilities and environmental constraints. |
| **126** | Define system performance (and constraints) specifications and the enabling/critical technologies verification plan. | Develop system performance (and constraints) specifications and enabling/critical technologies verification plan. | Assess the system performance (and constraints) specifications for an enabling/critical technologies verification plan. |
| **127** | Explain the functional definitions for enabling/critical technologies and associated verification plan. | Show the functional definitions for enabling/critical technologies and associated verification plan. | Appraise the functional definitions for enabling/critical technologies and associated verification plan. |
| **128** | Explain how functional definitions are decomposed into a critical component definition and technology verification plan. | Show how functional definitions are decomposed into a critical component definition and technology verification plan. | Appraise the decomposition of functional definitions into a critical component definition and technology verification plan. |

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| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **129** | Identify system concepts, including enabling/critical technologies; | Formulate system concepts, including enabling/critical technologies; | Assess system concepts, including enabling/critical technologies; |
| **130** | Describe changes to constraints and cost/risk drivers. | Evaluate changes to constraints and cost/risk drivers. | Assess the impact of changes to constraints and cost/risk drivers. |
| **131** | Differentiate enabling/critical technology components versus plan | Evaluate the use of enabling/critical technology components versus plan | Compare the use of enabling/critical technology components versus plan |
| **132** | Describe system functionality versus plan. | Illustrate the system functionality versus plan. | Contrast system functionality versus plan. |
| **133** | Differentiate the integrated system versus the performance specification. | Illustrate/model the integrated system versus the performance specification. | Assess the integrated system versus the performance specification. |
| **134** | Explain what the system concepts and technology maturity is versus defined user needs | Point out the system concepts and technology maturity versus defined user needs | Validate the system concepts and technology maturity versus defined user needs |
| **135** | | Identify that the TRs normally conducted during TD include SRR (which should provide an approved system performance specification, and several other metrics), IBR (which should establish the Performance Management Baseline, and assessment of risk within it), and a Technology Readiness Assessment (an evaluation of system technology maturity) | |
| **136** | | Identify that the outputs of TD include a system performance specification and a TEMP. | |

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| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **System Development and Demonstration** | | | |
| **137** | Recognize that in SDD, the program and the system architecture are defined based upon the selection and integration of the mature technology suite accomplished during CR and TD, | Identify that in SDD, the program and the system architecture are defined based upon the selection and integration of the mature technology suite accomplished during CR and TD, | Document that in SDD, the program and the system architecture are defined based upon the selection and integration of the mature technology suite accomplished during CR and TD, |
| **138** | Recognize that in SDD that system design requirements are allocated down to the major subsystem level, and are refined as a result of developmental and operational tests, and iterative systems engineering analyses. | Identify that in SDD that system design requirements are allocated down to the major subsystem level, and are refined as a result of developmental and operational tests, and iterative systems engineering analyses. | Document that in SDD that system design requirements are allocated down to the major subsystem level, and are refined as a result of developmental and operational tests, and iterative systems engineering analyses. |
| **139** | | Identify that in SDD, the support concept and strategy are refined | |
| **140** | Describe user needs, system performance specifications and environmental constraints, | Interpret user needs, system performance specifications and environmental constraints, | Formulate user needs system performance specifications and environmental constraints, |
| **141** | Define system functional specifications and system verification plan, | Develop system functional specifications and system verification plan, | Assess the system functional specifications and system verification plan, |
| **142** | Trace the functional performance specifications into Configuration Item (CI) functional (“design to”) specifications and CI verification plan | Convert functional performance specifications into Configuration Item (CI) functional (“design to”) specifications and CI verification plan | Change functional performance specifications into Configuration Item (CI) functional (“design to”) specifications and CI verification plan |
| **143** | Trace the CI functional specifications into product (“build to”) documentation and inspection plan | Convert CI functional specifications into product (“build to”) documentation and inspection plan | Change CI functional specifications into product (“build to”) documentation and inspection plan |

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| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **144** | Describe how to fabricate, assemble, or code to “build to” documentation, | Interpret what it means to fabricate, assemble, code to “build to” documentation, | Assess how to fabricate, assemble, code to “build to” documentation, |
| **145** | Explain verification of Individual CIs | Formulate verification of individual CIs | Assess verification of Individual CIs |
| **146** | Explain value of Developmental Test and Evaluation (DT&E), Integrated DT&E, Live Fire Test and Evaluation (LFT&E) and Early Operational Assessments (EOAs) verify performance compliance to specifications, | Interpret how Developmental Test and Evaluation (DT&E), Integrated DT&E, Live Fire Test and Evaluation (LFT&E) and Early Operational Assessments (EOAs) verify performance compliance to specifications | Assess how Developmental Test and Evaluation (DT&E), Integrated DT&E, Live Fire Test and Evaluation (LFT&E) and Early Operational Assessments (EOAs) verify performance compliance to specifications |
| **147** | Explain the value of System DT&E, LFT&E and OAs, to verify system functionality and constraints compliance to specifications | Interpret how System DT&E, LFT&E and OAs, verify system functionality and constraints compliance to specifications | Assess how System DT&E, LFT&E and OAs, verify system functionality and constraints compliance to specifications |
| **148** | Explain the value of combined DT&E/OT&E/LFT&E, to demonstrate the system to specified user needs and environmental constraints | Interpret how combined DT&E/OT&E/LFT&E, to demonstrate the system to specified user needs and environmental constraints | Assess how combined DT&E/OT&E/LFT&E, to demonstrate the system to specified user needs and environmental constraints |

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| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **149** | | Identify that the TRs normally conducted during SDD include IBR (for EVM contracts), SRR (which should provide an approved system performance specification, and several other metrics), SFR (which should provide an established system functional baseline, and several other metrics), PDR (which should provide an established system allocated baseline, and several other metrics), CDR (which should provide an established system product baseline, and several other metrics), TRR (which should ensure that the subsystem or system under review is ready to proceed into formal test), SVR (which should establish and verify final product performance and provide inputs to the creation of the CPD), PRR (which should assess the manufacturing and quality risk as the program proceeds into production), (TRA - an evaluation of system technology maturity), and perhaps OTRR (which ensures that the "production configuration" system can proceed into Operational Test and Evaluation (OT&E) with a high probability the system will successfully complete operational testing). | |
| **150** | | Identify that the outputs of SDD include an updated TEMP, SEP, risk assessment, TRA, and inputs for the CPD. | |

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| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **Production and Deployment** | | | |
| **151** | | Identify that the T&E process frequently reveals issues that require improvements or redesign, and that the initial manufacturing process may reveal issues that were not anticipated, or it may be discovered that changing the product somewhat may provide enhancements in the manufacturing process. | |
| **152** | Identify deficiencies to determine corrective actions | Analyze deficiencies to determine corrective actions | Assess deficiencies to determine corrective actions |
| **153** | Explain how to modify configuration (hardware, software, and specifications) as necessary to correct deficiencies | Interpret how to modify configuration (hardware, software, and specifications) as necessary to correct deficiencies | Assess modifications to the configuration (hardware, software, and specifications) as necessary to correct deficiencies |
| **154** | Explain what is meant by “Verify and Validate” the production configuration. | Interpret how to “Verify and Validate” production configuration | Assess how to “Verify and Validate” production configuration |

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| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **155** | | Identify that the technical reviews normally conducted during P&D include IBR (for EVM contracts), OTRR (which ensures that the "production configuration" system can proceed into Operational Test and Evaluation (OT&E) with a high probability the system will successfully complete operational testing), and PCA (confirms that the manufacturing processes, quality control system, measurement and test equipment, and training are adequately planned, tracked and controlled). | |
| **Operations and Support** | | | |
| **156** | | Identify that SE is involved in in-service reviews and trade studies and decisions regarding modifications, upgrades, and future increments of the system. This may include system upgrades for interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, Joint or service commonality, etc. | |

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| **SE by PHASES *** | | | |
| *** NOTE: Levels I and III will be reworked by DAU to reflect the most appropriate learning outcomes for these levels.** | | | |
| **157** | Describe the performance of the following SE activities: monitor and collect all service use data; analyze data to determine root cause of problem; determine the risk/hazard severity of the system; develop corrective action; integrate and test corrective action; assess risk of improvements; implement and field | Demonstrate the performance of the following SE activities: monitor and collect all service use data; analyze data to determine root cause of problem; determine the risk/hazard severity of the system; develop corrective action; integrate and test corrective action; assess risk of improvements; implement and field | |
| **158** | | Identify that the technical review normally conducted during O&S is the ISR (which should provide an overall System Hazard Risk Assessment, and an operational readiness assessment in terms of system problems (hardware, software, and production discrepancies)). | |
| **Disposal** | | | |
| **159** | | Identify compliance with applicable environmental regulations. | |

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| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE TOOLS AND TECHNIQUES** | | | |
| **Systems Engineering Plans** | | | |
| **160** | Identify the proper points within the program's lifecycle to generate and update a SEP | | Appraise the SEP process (how it describes the program's overall technical approach: processes, resources, metrics, and technical reviews.) |
| **161** | | Identify the critical contents of a SEP: government and contractor SE processes, technical baseline approach, and the relationship and integration of SE within the program management organization and to other program control tools such as the IMP, IMS, EVMS, and TPMs. | Critique SEPs for proper content and attributes. |
| **Work Breakdown Structure** | | | |
| **162** | Recognize how to translate system definition into a Work Breakdown Structure. | Explain the system products and services identified in the WBS. | Evaluate the WBS and the Systems Engineering activities that should be covered in the WBS. |
| **Value Engineering** | | | |
| **163** | | Illustrate how value engineering methodologies support the systems engineering process. | Evaluate the value engineering methodologies in relationship to systems engineering |
| **Technical Performance Measurement** | | | |
| **164** | Describe how TPM can be used as a SE metric to monitor contractor progress | Distinguish the role of TPM in the systems engineering process. | Evaluate TPM as a SE metric to monitor contractor progress in systems engineering planning. |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE TOOLS AND TECHNIQUES** | | | |
| **Trade Studies** | | | |
| **165** | Describe how TPM can be used as a SE metric to monitor contractor progress | Describe the studies planned to make trade-offs among stated requirements; design; project schedule; functional and performance requirements; function; task; and decision allocation between human, software, and hardware and life cycle/design to cost | Analyze trade-offs among stated requirements; design; project schedule; functional and performance requirements; function; task and decision allocation between human, software, and hardware and life cycle/design to cost |
| **166** | Identify the methods and tools for trade-off analyses, systems and cost effectiveness analyses, and risk management. | Describes the use of criteria for decision-making and trade-off of alternative design solutions. | Defend the use of criteria for decision-making and trade-off of alternative design solutions. |
| **167** | | Describe the MOEs, how they interrelate, and criteria for the selection of measures of performance (MOPs) to support the evolving definition and verification of the system. | Analyze how analytical results will be integrated. |
| **Modeling and Simulation** | | | |
| **168** | . | Examine how Modeling and Simulation can aid the SE process particularly in the pre-systems acquisition phases and during the SDD phase. | Explain how Modeling and Simulation can aid the SE process. |
| **Failure Modes, Effects, and Criticality Analysis (FMECA)** | | | |
| **169** | Recognize FMECA as a tool which analyzes potential failures to determine the effect on the entire system. | Apply FMECA and demonstrate its effect on cost, schedule, and performance objectives. | Specify appropriate use and tailored modification of FMECA as part of the systems engineering process to control cost, schedule, and performance. |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE TOOLS AND TECHNIQUES** | | | |
| **Requirements Traceability Matrix (RTM)** | | | |
| **170** | | Apply RTM to a specific systems engineering process and ensure through analysis that all requirements parent/child can be tracked, traced, identified, documented and verified. | Specify appropriate use and tailored modification of the RTM as a part of the systems engineering process to control performance objectives. |
| **Technical Data Packages** | | | |
| **171** | | Examine the purpose and timing of technical data packages. | Explain the purpose of the technical data package and other systems specific information over the system's lifecycle. |
| **Specifications** | | | |
| **172** | | Distinguish how the systems engineering process contributes to development of a system specification. | Explain the systems engineering activities that should be included in the system specification. |
| **Earned Value Management** | | | |
| **173** | Describe the principles of EV. | Calculate the earned value of a program during systems development. | Evaluate EV data and make recommendations to programmatic decisions makers based on the results of the data analysis. |
| **IMP/IMS** | | | |
| **174** | Describe the purpose of IMP/IMS and how they relate to the overall technical management framework | Modify an IMP/IMS in the technical scheduling and management of a program | Analyze an IMP/IMS for completeness as a tool for technical scheduling and management of project |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE TOOLS AND TECHNIQUES** | | | |
| **Technical Reviews** | | | |
| **175** | Describe the purpose of technical reviews and how they relate to the overall technical management framework. | Distinguish between the different technical reviews and show how the reviews map against the technical products required from each acquisition phase and technical phase of effort. | Distinguish between event-driven and schedule-driven technical review timing. |
| **176** | Identify the characteristics that make a review "integrated" and the role of independent subject matter experts. | Recognize the linkage of the technical reviews with the program technical baseline, the attributes of the individual technical reviews, and the span of review criteria. | Evaluate a proposed technical review plan, including the entry criteria, exit criteria, appropriateness of the proposed Chair, the risk assessment criteria, review elements, and participants. |
| **177** | Recognize the different types of technical reviews and how they are mapped against system technical maturity. | Formulate review checklists tailored to each review. | Assess the appropriateness of technical reviews in a program as proposed by the technical authority in terms of proper timing and effective conduct. |
| **178** | Describe the role of technical authority in technical reviews. | Formulate risk assessment criteria linked to each review covering the full span of technical risk issues applicable to each review. | Compose valid entry/exit criteria for a sample set of reviews |
| **179** | | Distinguish between reviews and identify entry and exit criteria for each type of technical review. | Assess the readiness of a program to conduct a given review. |
| **180** | | Plan a CDR together with who should chair, who should participate from the Contractor, Gov't, who should chair and what subject matter experts should attend. | Apply entry criteria best practice and determine whether a review should be conducted (against a case-study of an example program). |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **SE TOOLS AND TECHNIQUES** | | | |
| **181** | | Identify how effective technical reviews can help programs meet their cost, schedule, and performance objectives. | Explain the implications of premature conduct of the review on the program. Formulate risks associated with in adequate 3rd party subject matter expert participation. |
| **Safety Analysis** | | | |
| **182** | Recognize that Safety Analysis as implemented by Mil-Std-882D provides a tool for categorizing safety hazards and risks in standard universally understood terms and for identifying and tracking mitigating corrections. The results of this analysis allow for control of a program's cost, schedule, and performance objectives | Apply Safety Analysis to a specific system engineering process to ensure program performance cost, schedule, and performance objectives are met as well as system safety hazards and risks | Specify appropriate use and tailored modification of Safety Analysis as part of the system engineering process to control program cost, schedule, and performance objectives as well as system safety hazards and risks |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **DESIGN CONSIDERATIONS *** | | | |
| *** NOTE:** “Design Considerations” as listed in Chapter 4 (Systems Engineering) of the Acquisition Guidebook. Each design consideration should be covered to the extent necessary to fully cover each addressed in Chapter 4 content and Chapter 4 references. (Topics included under Design Considerations are Open Systems Design; Modular Open Systems Architecture; Architectures and Interoperability; Standardization; Software; COTS and NDI; Supportability; Manufacturing Capability and Producibility; Quality Assurance; Reliability, Availability, and Maintainability; Human Systems Integration; ESOH; Survivability; Corrosion Prevention and Control; Disposal and Demilitarization; Anti-Tamper; Information Assurance; Accessibility; System Security; Test and Evaluation; and Sustainment. | | | |
| **183** | | Identify the full set of design considerations that should be addressed as part of the overall systems engineering effort | |
| **184** | . | Recognize which of these considerations are statutory, which are regulatory, and which relate to operational effectiveness and suitability | |
| **185** | | Identify waiver processes that apply to statutory and/or regulatory requirements | |
| **186** | | Identify design consideration sources (applicable source documentation/guidance, cognizant organizations/offices) pertaining to these categories | |
| **187** | | Identify the full set of potential system constraints that need to be addressed and tracked together with other design considerations | |

| SPRDE/SE CAREER PATH LEARNING OUTCOMES BY CATEGORIES AND TOPICS | | | |
|---|---|---|---|
| **LO #** | **Level I** | **Level II** | **Level III** |
| **DESIGN CONSIDERATIONS *** | | | |
| **188** | | Explain how tradeoff analyses are key to understanding the system design implications across design considerations and constraints, and how this is an elemental part of the design process | |
| **189** | | Explain how design considerations are tracked to, and managed across, the system technical baseline. Show how system constraints should be addressed as part of the technical baseline definition | |
| **190** | | Show how these design considerations are addressed in each acquisition phase and are captured in technical baseline products unique to each phase | |
| **191** | | Explain how the technical reviews address and establish incorporation of these design considerations and constraints, and incorporation of agreements as to tradeoffs across these considerations and constraints by all stakeholders | |
| **192** | | Explain the role of stakeholders in managing expectations at each technical review | |
| **193** | | Explain the role of test and evaluation in evaluating system compliance in meeting design consideration expectations as documented in the technical baselines | |

**Appendix N**
**Education and Training Review "Tiers"**

## First Tier DAU Courses for SE Modification

| | |
|---|---|
| ***ACQ Courses **** | |
| ACQ 101 | Fundamentals of Systems Acquisition Management |
| ACQ 201 A&B | Intermediate Systems Acquisition |
| ACQ 401 | Senior Acquisition Course |
| ACQ 402 | Executive Management Course |
| ACQ 403 | Defense Acquisition Executive Overview Workshop |
| ACQ 404 | Systems Acquisition Management Course for General/Flag Officers ACQ 405 Executive Refresher Courses |
| ***PMT Courses **** | |
| PMT 250 | Program Management Tools |
| PMT 401 | The Program Manager's Course |
| PMT 402 | Executive Program Manager's Course |
| ***SAM Courses*** | |
| SAM 301 | Advanced Software Acquisition Management |
| ***SYS Courses*** | |
| SYS 101 (New) | Basic Systems Planning, Research, Development and Engineering |
| SYS 201 A&B | Intermediate SPRDE |
| SYS 301 | Advanced SPRDE |
| ***TST Courses*** | |
| TST 301 | Advanced Test and Evaluation |
| ***Continuous Learning Courses:*** | |
| Technical Reviews (New for 2004) | |
| System Safety Hazard Analysis (New for 2004) | |

* Note: level 4 courses could likely use the same SE module, and as an expedient could be covered by a guest lecturer

## Second Tier DAU Courses for SE Modification

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|---|---|
| ***LOG Courses*** | |
| LOG 101 | Acquisition Logistics Fundamentals |
| LOG 201 A&B | Intermediate Acquisition Logistics |
| LOG 203 | Reliability and Maintainability |
| LOG 204 | Configuration Management |
| LOG 235 A&B | Performance Based Logistics |
| LOG 304 | Executive Life Cycle Logistics Management |
| ***PMT Courses*** | |
| PMT 352 A&B | Program Management Office Course |
| PMT 403 | Program Manager's Skills |

| | |
|---|---|
| ***SAM Courses*** | |
| SAM 101 | Basic Software Acquisition Management |
| SAM 202 | Intermediate Software Acquisition Management |
| ***TST Courses*** | |
| TST 101 | Introductions to Acquisition Workforce Test and Evaluation |
| TST 202 | Intermediate Test and Evaluation |
| ***Others*** | |
| Selected BCF (e.g., Cost, EVM, Risk Analyses Courses) | |
| Selected CON Courses | |
| All the PQM Courses | |
| ***STM Courses*** | |
| STM 302 | Systems Engineering for S&T Managers |

Note: Either the name of the course needs to be changed, or the curriculum needs to be changed to truly contain SE addressed with some rigor, remembering that there is no requirement for ACQ 101/201 in this career field.

# Appendix O
# PM and ACQ Course Summaries

## PM AND ACQ COURSE SUMMARIES

### ACQ101: Fundamentals of Systems Acquisition Management

**Course Description:** This course provides a broad overview of the DoD systems acquisition process, covering all phases of acquisition. It introduces the requirements generation and resource allocation processes, the DoD 5000 Series documents governing the defense acquisition process, and current issues in system acquisition management. Designed for individuals who have little or no experience in DoD acquisition management, ACQ101 has proven very useful to personnel in headquarters, program management, and functional or support offices.

**Objectives:** Students who successfully complete this course will be able to recognize:

- the fundamental precepts and bases of defense systems acquisition management;
- the diverse, interrelated, and changing nature in the different disciplines of defense systems acquisition management; and
- the regulations and governing structures of defense systems acquisition management

**Audience:** This course is designed for military officers, O-1 through O-3, and DoD civilians, GS-5 through GS-9. However, the course is open to all ranks and grades.

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|---|---|
| **Prerequisite:** None | **Recommended:** NA |
| **Method of Delivery:** Distance Learning | **Length:** This is a nonresident, self-paced course available through the Internet. Students must pass the final examination within 60 calendar days of the start date. |

**IDA Notes:** We have all the TLOs and ELOs for this course; the SE module TLOs and ELOs are in file "Acq SE Comp TLO ELO Summary.doc", along with the ACQ SE competencies. Once the SPRDE/SE performance objectives are blessed by the SE Office and the SPRDE/SE FIPT, someone will have to do a crosswalk between them and the ACQ SE competencies. Also, the SYS 101 course will affect what SE competencies remain in the ACQ 101 course.

### ACQ201A: Intermediate Systems Acquisition (Part A)

**Course Description:** Intermediate Systems Acquisition, Part A, uses computer-based training to prepare mid-level acquisition professionals to work in integrated product teams by understanding systems acquisition principles and processes. Both ACQ201A and ACQ201B are required for DAWIA certification.

**Objectives:** Students who successfully complete this course will:

- enhance their knowledge of the business, technical, and managerial aspects of acquisition;
- understand and appreciate the critical role that each functional discipline plays in the acquisition process; and
- using computer-based training, theoretically participate in simulated integrated product teams to develop plans and resolve problems

**Audience:** ACQ201A is for military officers, O-3 and above; civilian, GS-9 and above; and industry equivalents who are Level I certified in acquisition. Students should have 2 to 4 years of acquisition and/or logistics experience

| | |
|---|---|
| **Prerequisite:** ACQ101 | **Recommended:** NA |
| **Method of Delivery:** Distance Learning | **Length:** This is a nonresident, self-paced course available through the Internet. Students must pass the final examination within 60 calendar days of the start date. |

**IDA Notes:** We have all the TLOs and ELOs for this course; the SE module TLOs and ELOs are in file "Acq SE Comp TLO ELO Summary.doc", along with the ACQ SE competencies. Once the SPRDE/SE performance objectives are blessed by the SE Office and the SPRDE/SE FIPT, someone will have to do a crosswalk between them and the ACQ SE competencies.

## ACQ201B: Intermediate Systems Acquisition (Part B)

**Course Description:** Intermediate Systems Acquisition, Part B, prepares mid-level acquisition professionals to work effectively in integrated product teams by understanding systems acquisition principles and processes. Both ACQ201A and ACQ201B are required for DAWIA certification

**Objectives:** Students who successfully complete this course will:

- enhance and apply their knowledge of the business, technical, and managerial aspects of acquisition;
- understand and appreciate the critical role that each functional discipline plays in the acquisition process; and
- effectively participate in integrated product teams and apply knowledge gained in ACQ201A to develop plans and resolve problems

**Audience:** ACQ201B is for military officers, O-3 and above; civilian, GS-9 and above; and industry equivalents who are Level I certified in acquisition. Students should have 2 to 4 years of acquisition and/or logistics experience

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|---|---|
| **Prerequisite:** ACQ201A | **Recommended:** NA |
| **Method of Delivery:** Resident/On-site | **Length:** 5 class days |

**IDA Notes:** See above.

## ACQ401: Senior Acquisition Course

**Course Description:** A preeminent course for members of the Acquisition Corps, ACQ 401 is designed to prepare selected military officers and civilians for senior leadership and staff positions throughout the acquisition community.

**Objectives:** Students who successfully complete this course are awarded a Master's of Science Degree in National Resource Strategy.

The Senior Acquisition Course consists of the entire 10-month Industrial College of the Armed Forces (ICAF) curriculum. The curriculum is enhanced for designated acquisition students through four major elements:

- the core curriculum,
- mandatory acquisition policy advanced studies,
- advanced studies electives, and
- research

**Audience:** Students are selected by their respective Services or agencies. Military officers are selected as part of the Senior Service School Selection Process and designated by the Directors, Acquisition Career Management

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|---|---|
| **Prerequisite:** None | **Recommended:** NA |
| **Method of Delivery:** Resident | **Length:** 10 months |

**IDA Notes:** All NDU acquisition courses are related at least somewhat to systems engineering, but aren't directly systems engineering courses. For example, acquisition core courses include the Requirements Generation Process, Risk Management, and Product Development.

## ACQ402: Executive Management Course

**Course Description:** The Executive Management Course is for individuals who are not graduates of PMT 301; PMT 302; or PMT 352, Parts A and B. This 3-week course serves senior managers who interface with, or otherwise need to understand, the defense systems acquisition process. Participants explore better ways to support, guide, and oversee acquisition programs through case studies and examples, faculty discussion, and guest speakers from the DoD community and the defense industry.

**Objectives:** Students who successfully complete this course will be able to:

- recognize what issues are important in defense systems acquisition at the executive level, and
- understand why these particular issues are important from a macro-perspective

**Audience:** This course is open to military officers and civilians, O-6/GS-15, who are working in positions requiring an understanding and working knowledge of DoD systems acquisition. Additionally, participants of equivalent rank, from defense industry, other Federal agencies, and allied nations, are admitted on a space-available basis

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|---|---|
| **Prerequisite:** None | **Recommended:** NA |
| **Method of Delivery:** Resident | **Length:** 15 class days |

**IDA Notes:** The SE Office probably needs to have someone collect relevant SE case studies and examples and have available personnel who can function as guest speakers.

## ACQ403: Defense Acquisition Executive Overview Workshop

**Course Description:** This innovative course provides general/flag officers and Senior Executive Service (SES) civilians with an executive-level understanding of the defense systems acquisition process. The workshop curriculum is 100 percent tailored to the specific needs of the participant, conducted "on demand," and delivered in a one-on-one desk-side forum.

**Objectives:** General/flag officers and SES civilians who successfully complete this course will:

- augment their knowledge of specific aspects of defense systems acquisition in one-on-one forum,
- gain an appreciation of the entire spectrum of the defense acquisition process or a limited number of specific areas within the process, and
- experience "just-in-time" learning and apply this tailored learning directly to real-time issues

**Audience:** This workshop is available to all DoD general/flag officers, political appointees, congressional staffers, and SES civilian employees. Membership in an Acquisition Corps career program is not required.

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|---|---|
| **Prerequisite:** None | **Recommended:** NA |
| **Method of Delivery:** Resident | **Length:** Variable, depending upon the number of topics to be addressed; typically one-half or 2 days |

**IDA Notes:** The systems engineering relevancy for this course is based on the student asking the right questions. If the SE policies get implemented, such as E10, then there should be a demand for answers to questions on SE in acquisition. Bob says that he gets asked questions all the time. By directing people to the right DAU course to answer SE questions, the courses will, by necessity, have to incorporate SE material. It might be useful to find out if DAU keeps a list of the questions asked, to find out what they have been in the past.

## ACQ404: Systems Acquisition Management Course for General/Flag Officers

**Course Description:** This 1-week course for general/flag officers and SES civilians focuses on understanding the perspectives of key government and defense industry decision makers. The course includes discussions of topics affecting the defense systems acquisition environment. Participants who are not graduates of PMT 301, PMT 302, PMT 352, Parts A and B; or PMT 401 will develop an executive-level understanding of defense systems acquisition management.

**Objectives:** Students who successfully complete this course will:

- gain an executive-level understanding of defense systems acquisition in terms of what is important and why it is important;
- understand recent legislation and executive actions affecting acquisition;
- refresh their knowledge of current DoD acquisition policy and procedural initiatives;
- appreciate the perspectives of the Congress, defense industry, and executives of the Office of the Secretary of Defense; and
- apply lessons learned and hot topics to their current acquisition programs

**Audience:** This course is for general/flag officers and SES civilians who are working in positions requiring an understanding of DoD systems acquisition. Also, participants of equivalent rank from defense industry, other Federal agencies, and allied nations are admitted on a space-available basis

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|---|---|
| **Prerequisite:** None | **Recommended:** NA |
| **Method of Delivery:** Resident | **Length:** 5 class days |

**IDA Notes:** Again, once SE policy is implemented, this course will need to include it. Guest speakers may also need to be supplied.

## ACQ405: Executive Refresher Course

**Course Description:** The Executive Refresher Course provides an acquisition policy, process, and lessons-learned update. The class members examine their role as acquisition leaders in a changing environment. Guest speakers lead discussions on contemporary management and leadership topics, such as reform initiatives, partnering with industry, contracting tools, resource allocations, downsizing, earned value oversight, performance-based logistics, and supply chain management.

**Objectives:** Students who successfully complete this course will be able to:

- understand acquisition management policies, processes, regulations, and statutes; and
- develop a leadership role in a changing acquisition management environment

**Audience:** This course is open to members of all career fields who are graduates of PMT 301, PMT 302, or PMT 352B; in addition, these graduates must have (or have been selected for) the rank/grade of O-6 or GS-15 or the industry equivalent thereof. Applicants who are not graduates of PMT 302 or PMT 352B but meet the rank/grade requirement should attend ACQ 402

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| **Prerequisite:** PMT 352B | **Recommended:** NA |
| **Method of Delivery:** Resident | **Length:** 10 class days |

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| | **IDA Notes:** Once SE policy is implemented, this course will have to include it as one of the contemporary management and leadership topics. The SE Office will probably have to have available personnel to serve as guest speakers. |
| **PM LevelI** | |
| | **Course Description:** There is no Level I course for the PM career field. The competencies below feed into the ACQ 101 course, as do Level I competencies from other career fields. |
| | **IDA Notes:** The Level I PM competencies in SE include:<br>--Explain how the Work Breakdown Structure (WBS), an output of the systems engineering process, breaks work into product-oriented elements and work processes allowing acquisition personnel to manage risk at levels lower than the overall system.<br>--Understand that the Systems Engineering Process is the process of technical management in the defense environment, and how it is used in translating user requirements into an integrated, system design solution.<br>--Understand the complexity of software development, its integral nature to the Systems Engineering Process (SEP), and top-level "best practices" for successful software development. |
| **PMT250: Program Management Tools** | |
| | **Course Description:** The Program Management Tools course provides application skills needed in a program office or as an Integrated Product Team (IPT) lead. It is a follow-on to ACQ201B and is designed to enhance journeyman-level skills. It is required, along with ACQ201B, for Level II certification in Program Management (PM) and also prepares students for later work in the Level III Program Management Office Course, PMT 352, Parts A and B. |
| | **Objectives:** Students who successfully complete this course will be able to:<br>- apply best practices for establishing effective IPTs,<br>- develop Work Breakdown Structures (WBSs),<br>- build program schedules and apply risk management principles using state-of-the-industry software,<br>- apply current cost estimating processes,<br>- perform contract planning and post-award activities, and<br>- use earned value tools and techniques for program planning and control |
| | **Audience:** Target attendees are civilians, GS-12/13, and military officers, O-3/O-4, in the PM career field. Lower grades may apply if they have completed ACQ201B. Personnel who were certified Level II in PM prior to 1 October 2001, or are certified Level III in other career fields, who want to take PMT 352 A and B, may obtain credit for PMT 250 by passing an equivalency exam. |
| | **Prerequisite:** ACQ201B<br>**Recommended:** NA |

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| | **Method of Delivery:** Distance Learning | **Length:** This is a nonresident, distance learning course available through the Internet. The course length is 73 calendar days. Students must complete modules 1-8 (consisting of about 56 hours of work) within 60 calendar days of the start date. Module 9 is an exercise-based "virtual classroom" using a combination of teleconferences and the Internet and requiring 24 hours of work over the last 4 days of the course. There is a 9-day gap between the online portion (days 1 through 60) and the virtual classroom (days 70 through 73). |
| | **IDA Notes:** We have all the TLOs and ELOs for this course; an SE ELO appears as follows under the TLO "Given a scenario, produce program and contract WBS":<br>--Employ a systems engineering process to develop a hierarchical product description<br><br>The Level II PM competencies in SE include:<br>--Apply the systems engineering process to transform requirements and constraints into an operational system design.<br>--Understand the role of various systems analysis and control tools (e.g., Work Breakdown Structure (WBS), technical performance measurements, trade studies, and modeling and simulation) in the systems engineering process.<br>--Illustrate the role of test and evaluation (DT&E, OT&E, LFT&E) in the systems engineering and acquisition management processes.<br>--Understand the role of manufacturing considerations in the Systems Engineering Process throughout the acquisition life cycle. | |
| **PMT352A: Program Management Office Course, Part A** | | |
| | **Course Description:** The Program Management Office Course (PMOC), Part A, is the first part of the Level III certification course in the Program Management (PM) career field. It is a follow-on to ACQ201B and PMT250 and is designed to train Level III leaders in a program office by honing analysis, synthesis, and evaluative skills. PMT352A focuses on key PMO knowledge and skills not covered in the prerequisite courses. | |
| | **Objectives:** Students who successfully complete this course will be able to:<br>- describe the role of science and technology in supporting the system acquisition process;<br>- understand Information Technology assurance measures, and interoperability considerations;<br>- describe current manufacturing and logistics concepts and best practices such as lean manufacturing and supply chain management; and<br>- explain appropriate management and decision-making models to aid in addressing various acquisition program issues (business and financial; international; environmental, safety and health, etc.) | |

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| | **Audience:** Target attendees are civilians, GS-13/14, and military officers, O-4/O-5, in the PM career field. Personnel certified at Level III in other career fields desiring to take PMOC for Level III PM certification must first complete PMT250 | |
| | **Prerequisite:** PMT250 | **Recommended:** NA |
| | **Method of Delivery:** Distance Learning | **Length:** This is a non-resident, self-paced course available through the Internet. Students must pass the final examination within 120 calendar days of the start date. |
| | **IDA Notes:** We don't have the materials for this course, although we do have the Level III PM Competencies, which for SE include:<br>--Originate tailored, value added, program documentation (e.g. Acquisition Program Baseline, Risk Management Plan, budget estimates, Software Acquisition Plan, Systems Engineering Plan), with application of commercial best practices where appropriate.<br>--Evaluate and manage a systems engineering process to translate requirements into integrated design solutions, ensuring that solutions both meet current requirements and facilitate the incorporation of new technologies and capabilities to meet future needs. | |
| **PMT352B: Program Management Office Course, Part B** | | |
| | **Course Description:** The Program Management Office Course (PMOC), Part B, is the second part of the Level III certification course in the Program Management (PM) career field. PMOC is a follow-on to ACQ201 and PMT250. The classroom component of PMOC, PMT352B, follow PMT352A, which is the prerequisite distance learning component of PMOC. These courses are designed to train Level II qualified students to be effective PM Level III leaders in a program office by honing analysis, synthesis, and evaluative skills. PMT352B features scenario-based practical exercises with topical themes, such as interoperability, prototyping, and evolutionary acquisition. | |
| | **Objectives:** Students who successfully complete this course will be able to:<br>- lead and contribute to effective teams in a DoD PMO;<br>- apply critical-thinking and problem-solving skills to system acquisition problems throughout a defense systems life cycle;<br>- understand, analyze, and develop solutions to cost, schedule, and performance issues faced in defense program management; and<br>- evaluate the tradeoffs in program decisions in compliance with DoD 5000 Series directives | |
| | **Audience:** Target attendees are civilians, GS-13/14, and military officers, O-4/O-5, in the PM career field. | |
| | **Prerequisite:** PMT352A | **Recommended:** NA |
| | **Method of Delivery:** Resident | **Length:** 6 weeks |

| | | |
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| | **IDA Notes:** See above. Also, the SE Office needs to have someone develop or collect scenario-based practical exercises so that this course can include the topical theme of systems engineering. | |
| **PMT401: The Program Manager's Course** | | |
| | **Course Description:** This course is an intense, highly integrated 10-week case-study-based learning experience. Group discussions, distinguished guest practitioners, team projects, exercises, simulations, study groups, and an elective program enable the learner to customize a portion of the course. Time will be available to internalize the material through independent study and informal work with peers. Course content will rely upon challenges, problems, and dilemmas derived from extensive current interviews with Program Managers (PMs), Program Executive Officers (PEOs) and other stakeholders. The dilemmas will be those that course graduates can expect to confront when they return to their workplaces | |
| | **Objectives:** Learners who successfully complete this course will be able to:<br>- apply critical thinking when confronted by problems and dilemmas on a day-to-day basis,<br>- lead and integrate disparate functional groups and develop a cohesive team capable of coping with the complex problems common to Program Management Offices (PMOs) and PEOs, and<br>- identify and apply best business practices to achieve win-win relationships with industry partners | |
| | **Audience:** This course is designed for specially selected Level III certified PM career field members who have demonstrated the potential to become managers or deputies of ACAT I or II programs or managers of major ACAT III programs. Other specially selected DoD AT&L workforce members who are motivated and capable of becoming managers of major integrated product teams, department or division heads in acquisition commands, or senior managers in laboratories and/or research and development centers also may attend. This assignment-specific course is statutorily required for newly selected PEOs, DPEOs, and PMs/DPMs of ACAT I, IA, and II programs. Participants must be O-5/GS-14 or above with extensive experience in acquisition, including 4 years in, or in direct support of, a PMO | |
| | **Prerequisite:** PMT352B for PM career field; recommended for other career fields; A Secret clearance is required | **Recommended:** NA |
| | **Method of Delivery:** Resident | **Length:** 10 weeks |

**IDA Notes:** We were told that the two 400-level courses are pretty much designed for the specific students and a lot of the material is based on the types of questions they ask. Any teaching materials DAU may have for the course may or may not be used. Perhaps the challenge is to get the PMs to ask the right questions. The SE Office also needs to have someone develop case studies of good SE practices.

The Level IV PM competency for SE is:

--Apply system engineering processes and assess the contractor's system engineering activities and products including logistics support and manufacturing analysis.

## PMT402: Executive Program Manager's Course

**Course Description:** This is an assignment-specific course designed to meet the learning and performance needs of newly selected Program Executive Officers (PEOs), Deputy PEOs (DPEOs), and ACAT I (ID/IC and IAM/IAC) and II Program Managers (PMs)/ Deputy Program Managers (DPMs). Skills and behaviors are developed through a concentrated 4-week resident period preceded by approximately 60 days of self-assessment and assessment of your program and program office

**Objectives:** Students who successfully complete this course will be able to:

- compete a comprehensive assessment of their programs, program offices, and of themselves;
- identify program and program office issues;
- fill knowledge needs and work issues; and
- develop a plan of action to better manage their programs, program offices, and professional development

**Audience:** This assignment-specific course is statutorily required for newly selected PEOs; DPEOs; and ACAT I, IA, and II PMs/DPMs prior to assuming the position. ACAT III PMs/DPMs, allied personnel, and industry students are eligible to attend on a space-available basis

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| **Prerequisite:** Either PMT302 or PMT352 and PMT401 | **Recommended:** NA |
| **Method of Delivery:** Resident | **Length:** PMT402A - 2 day resident workshop; PMT402B - 20 class days |

**IDA Notes:** See above.

We do have some material on this course to review, such as the course overview briefing charts, the draft master schedule, the Syllabus, the Assessment Status Briefing Guide, and the Learner's Program Assessment Guide (we believe that these assessments formulate the questions discussed above during the 2-day resident workshop). These could be tailored to ensure an assessment of the SE part of the PM's program. The Syllabus contains an interesting teaching note on the *Systems Perspective*.

# Appendix P
# ACRONYMS

# ACRONYMS

| | |
|---|---|
| AET&CD | Acquisition Education, Training, and Career Development |
| AFIT | Air Force Institute of Technology |
| AMC | Army Materiel Command |
| AMSDL | Acquisition Management System Data List |
| AoA | Analysis of Alternatives |
| APB | Acquisition Program Baseline |
| ASR | Alternative System Review |
| AT&L | Acquisition, Training and Logistics |
| BCEFM | Business, Cost Estimating, and Financial Management |
| CAD | Computer Aided Design |
| CAE | Computer Aided Engineering |
| CAIV | Cost As an Independent Variable |
| CAM | Computer Aided Manufacturing |
| CARD | Cost Analysis Requirements Document |
| CCB | Configuration Control Board |
| CDD | Capability Development Document |
| CDR | Critical Design Review |
| CDRL | Contract Data Requirements List |
| CDSC | Curriculum Development Support Center |
| CI | Configuration Item |
| CLM | Continuous Learning Module |
| CM | Configuration Management |
| CMMI | Capability Maturity Model Integration |

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|---|---|
| CMOAIPT | Career Management Overarching Integrated Product Team |
| COTS | Commercial Off the Shelf |
| CPD | Capabilities Production Document |
| CPR | Cost Performance Reporting |
| CRD | Capstone Requirements Document |
| CSAP | Course Student Assessment Plan |
| DAB | Defense Acquisition Board |
| DAU | Defense Acquisition University |
| DAWIA | Defense Acquisition Workforce Improvement Act |
| DCMA | Defense Contract Management Agency |
| DID | Data Item Description |
| DII COE | Defense Information Infrastructure Common Operating Environment |
| DoD | Department of Defense |
| DoDD | Department of Defense Directive |
| DoDI | Department of Defense Instruction |
| DOTMLPF | Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities |
| DS | Defense Systems |
| DSB | Defense Science Board |
| DSOC | Defense Safety Oversight Council |
| DT&E | Developmental Test and Evaluation |
| EA | Evolutionary Acquisition |
| ECP | Engineering Change Proposal |
| ET&E | Education, Training and Experience |
| ELO | Enabling Learning Objective |
| ESOH | Environmental, Safety and Occupational Health |

| | |
|---|---|
| EV | Earned Value |
| EVM | Earned Value Management |
| FA | Functional Advisor |
| FAA | Functional Area Analysis |
| FFBD | Functional Flow Block Diagram |
| FIPT | Functional Integrated Product Team |
| FoS | Family of Systems |
| FNA | Functional Needs Analysis |
| FSA | Functional Solution Analysis |
| GAO | Government Accounting Office |
| IBR | Integrated Baseline Review |
| ICD | Initial Capabilities Document or Interface Control Document |
| ICWG | Interface Control Working Group |
| IDA | Institute for Defense Analyses |
| ILSP | Integrated Logistics Support Plan |
| INCOSE | International Council on Systems Engineering |
| IPPD | Integrated Product and Process Development |
| IPT | Integrated Product Team |
| ISR | Industrial Security Regulation |
| IT | Information Technology |
| ITR | Initial Technical Review |
| IV&V | Independent Verification and Validation |
| JCIDS | Joint Capabilities Integration Development System |
| JROC | Joint Requirements Oversight Council |
| JTA | Joint Technical Architecture |
| KPP | Key Performance Parameter |
| LFT&E | Live Fire Test and Evaluation |

| | |
|---|---|
| LMI | Logistics Management Institute |
| LRIP | Low Rate Initial Production |
| LSA | Logistics Support Analysis |
| LO | Learning Outcomes |
| MAIS | Major Automated Information System |
| MCSC | Marine Corps System Command |
| MDA | Milestone Decision Authority |
| MNS | Mission Needs Statement |
| MOP | Measure of Performance |
| M&S | Modeling and Simulation |
| MS | Milestone |
| NACE | National Association of Corrosion Engineers |
| NDI | Non Developmental Item |
| NPS | Naval Post Graduate School |
| NSA | National Security Agency |
| ORD | Operational Requirements Document |
| OT&E | Operational Test and Evaluation |
| OTRR | Operational Test Readiness Review |
| OUSD | Office of the Under Secretary of Defense |
| PCR | Physical Configuration Review |
| PCD | Position Category Description |
| PDR | Preliminary Design Review |
| PM | Program Management or Program Manager |
| PPBE | Planning, Programming, Budgeting, and Execution |
| PPBES | Planning, Programming, Budgeting, and Execution System |
| PRR | Production Readiness Review |
| PQM | Production, Quality and Manufacturing |

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|---|---|
| PRR | Production Readiness Review |
| PSC | Preferred System Concept |
| QRE | Quick Reaction Element |
| RDT | Rapid Deployment Training |
| RFD | Request for Deviation |
| RFP | Request for Proposal |
| RTOC | Reduction of Total Ownership Cost |
| SAF | Secretary of the Air Force |
| SAR | Selected Acquisition Report |
| SDD | System Development and Demonstration |
| SE | Systems Engineering |
| SEBoK | Systems Engineering Body of Knowledge |
| SEP | Systems Engineering Plan |
| SFR | System Functional Review |
| SME | Subject Matter Expert |
| SOO | Statement of Objectives |
| SoS | System of Systems |
| SOW | Statement of Work |
| Space BAR | Space Broad Area Review |
| SPRDE | Systems Planning, Research, Development, and Engineering |
| SRR | System Requirements Review |
| SSP | Signals Intelligence (SIGINT) Support Plan |
| STM | Science and Technology Manager |
| SVR | System Verification Review |
| SW | Software |
| TAA | Technology Area Assessment |
| TAP | Technology Area Plan |

| | |
|---|---|
| TDS | Technology Development Strategy |
| T&E | Test and Evaluation |
| TEMP | Test and Evaluation Master Plan |
| TLO | Terminal Learning Objective |
| TOC | Total Ownership Cost |
| TPM | Technical Performance Measurement |
| TRR | Test Readiness Review |
| UML | Unified Modeling Language |
| USD | Undersecretary of Defense |
| VV&A | Verification, Validation and Accreditation |

| REPORT DOCUMENTATION PAGE | *Form Approved*<br>*OMB No. 0704-0188* |
|---|---|



| 1. REPORT DATE (DD-MM-YY) | 2. REPORT TYPE | 3. DATES COVERED (From – To) |
|---|---|---|
| December 2004 | Final | |

**4. TITLE AND SUBTITLE**
Developing Education and Training Requirements for the Systems Planning, Research, Development, and Engineering/Systems Engineering Career Path

**5a. CONTRACT NO.** DASW01 04 C 0003

**5b. GRANT NO.**

**5c. PROGRAM ELEMENT NO(S).**

**6. AUTHOR(S)**
Margaret R. Porteus, Christina M. Patterson, Karen J. Richter

**5d. PROJECT NO.**

**5e. TASK NO.** AB-6-2271

**5f. WORK UNIT NO.**

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Institute for Defense Analyses
4850 Mark Center Drive
Alexandria, VA 22311-1882

**8. PERFORMING ORGANIZATION REPORT NO.**
IDA Paper P-3951

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
Office of Enterprise Development
OUSD(AT&L)/DS/SE/ED
Room 3D1075
Washington, DC 20301

**10. SPONSOR'S / MONITOR'S ACRONYM(S)**
OUSD(AT&L)/DS/SE/ED

**11. SPONSOR'S / MONITOR'S REPORT NO(S).**

**12. DISTRIBUTION / AVAILABILITY STATEMENT**
Approved for public release; distribution unlimited.

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**
This paper presents IDA's participation in a review, conducted during FY 2004, of systems engineering-related education and training for the acquisition workforce. The purpose of the review was to determine ways that the education and training could be revised or updated to achieve better implementation of systems engineering on acquisition programs. Most of the work centered on the courses offered within the Systems Engineering (SE) career path of the Systems Planning, Research, Development and Engineering (SPRDE) career field. This paper begins with background leading up to the review, summarizing recent changes to DoD acquisition policy and SE policy. The remainder of the paper documents the implementation of the review, highlighting IDA's participation. It includes proposed revisions and updates to the SPRDE/SE position category description, certification requirements, and other education and training-related resources as well as guidance regarding certification course content.

**15. SUBJECT TERMS**
systems engineering, education and training requirements, acquisition workforce competencies and certification, Systems Planning, Research, Development and Engineering (SPRDE) career field, Systems Engineering (SE) career path, SPRDE/SE certification

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NO. OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | Mr. Merrill Yee |
| U | U | U | UU | 374 | 19b. TELEPHONE NUMBER (Include Area Code)<br>(703) 693-7637 |